Fourth National Forum

on

Information Management

and

GIS

in the

Geosciences

START

Fourth National Forum
on
Information Management and GIS in the Geosciences

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4^{th} National Forum

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Preface and Acknowledgements

On the eve of a new century the **4^{th} National Forum on Information Management and GIS in the Geosciences** has come and gone. The planning is over and the 'wash-up' meeting has been held and documented to assist those coordinating the next Forum in 2001.
I am pleased to report, with some relief, that just over 150 registered for the Forum, an excellent result considering the present state of mineral and petroleum exploration in Australia, and the world for that matter.

The scope of this Forum was to encourage the flow of ideas and experience, and provide participants with the opportunity to gain an up-to-date understanding of the rapidly changing developments in data management and GIS. More specifically the objectives were to:

- review and discuss strategies and systems for managing geoscientific data and information;
- review strategies for migrating spatial data into a unified corporate data environment;
- demonstrate new and innovative uses of GIS and visualisation in the geosciences; and
- review best practice in the application of GIS in government and industry with regard to standards, procedures, geoscience related applications and allied technology.

By all reports we achieved these objectives primarily through the presentation of high quality papers, but the 'Industry Feedback Session' and informal discussion also contributed to the exchange of information. The decision to incorporate information management as a theme along with GIS in the Forum was fitting and highlighted the interplay between the two when dealing with spatial information.

My sincere thanks to Mr Ken Granger for stepping in, at almost the last minute, to present the keynote address. His presentation set the scene for the Forum, in more ways than one, by drawing out the relationship between IM and GIS for decision support, and introducing the broader application of geoscience as a fundamental theme in sustainable development and community safety.

The State, Territory and Commonwealth reports provided a candid insight to the implementation of data management programs around the country that are aimed at providing ease of access to geoscience data. Additionally, geological survey and industry representatives presented some interesting and varied applications of GIS and related technologies, which emphasised the reliance on well-managed and accessible data.

On behalf of AGSO and the Organising Committee, thank you to all the authors and presenters of papers. This year we have decided to distribute the Proceedings of the Forum on a CD to overcome the constraints we had previously with printing costs. I commend the ***Proceedings of the 4th National Forum on Information Management and GIS in the Geosciences*** to you and hope that you find it a useful reference resource.

Acknowledgements:
The patron of this Forum is the Government Geoscience Information Policy Advisory Committee (GGIPAC), which was established by the Chief Government Geologists, who, in turn, report to the Australian and New Zealand Minerals and Energy Council (ANZMEC) – a peak States/Federal Ministerial Council.

My thanks to the Organising Committee and AGSO staff, whose effort and professionalism contributed to the success of the Forum.

Editor's comment:
Authors were requested to submit papers in digital form according to prescribed guidelines and no editing has been performed on their content. The content of the papers in this Record reflects the opinion of the authors and may or may not represent the views of AGSO.

Ian O'Donnell
Forum Convenor
9 April 1999

Fourth national forum on information management and GIS in the geosciences

National Library of Australia, Canberra, 24–25 March 1999
Program

Welcome and opening, *The Hon Warren Entsch MP, (Parliamentary Secretary to the Federal Minister for Industry, Science & Resources)*

Keynote address: Information management and decision making: is too much information ever enough? *Ken Granger, AGSO*

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9. Characterising hydrocarbon seepage in Australia's Timor Sea (Yampi Shelf) using integrated remote sensing technologies, *Geoffrey W. O'Brien, Michael Morse (AGSO) Paul Quaife (Resource Management (Australia) Pty Ltd), Shawn Burns (RadarSat International), & John Payne (AUSLIG)*
10. AGSO petroleum data model perspective : essential elements for geoscience data models, *John Bradshaw & Bruce Wyatt, (AGSO)*
11. FracSIS — a three-dimensional spatial information system for the geosciences, *Robert Woodcock & Nicholas Archibald (Fractal Graphics)*
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13. Data management- basics revisited, *Craig Bentley (NTGS)*
14. A common geoscientific environment at NSW DMR: Introduction to COGENT database, *Scott McDonell*; Mapping and production process, *Jim West;* Metadata system, *Peter Lewis and Scott McDonell (NSWDMR)*
15. Spatial information management via the Internet and Intranets, *Jonathon Root (AGSO)*
16. The DIGS system process of converting geological reports into digital form and delivery of the reports to the clients, *Geoff Brookes (NSWDMR)*
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18. GIS and data management in BHP – 2 years on, *Lili Haas (BHP)*

19. Decentralised GIS — an MIM perspective, *P.M. Jayawardhana, S.N. Sheard, & P.J. Forrestal (MIM)*
20. Analysing digital data sets on a national scale - what are the essentials? *Anthony Budd, Irina Bastrakova, Bruce Kilgour & Lesley A.I. Wyborn (AGSO)*
21. GIS compatibility of digitally reported exploration data, *David Jenkins & Simon Beams (Terra Search)*
22. Modern mineral potential modelling, quantitative resource assessment and the valuation of geoscientific data, *Margaretha Scott (Qld DME)*
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24. GIS linking to external data sets and processes, *Ken Moule (Exa-Min Resource Industry Consultants Pty Ltd)*
25. Integrating databases with GIS at Pasminco Exploration: The first steps, *Stephen Winter (Pasminco)*
26. Focusing exploration in the Kanmantoo Trough, *J.C. Gum & A.C. Burtt (PIRSA)*
27. Application of GIS to sustainable catchment and land resource management, *Dhia Al Bakri & Josine McInness (Orange Agricultural College, University of Sydney)*

1. 28(i). AGSO's ArcView extension helps define the outer limit of Australia's marine jurisdiction, *Irina Borissova[1] , Robin Gallagher[2], Philip A. Symonds[1], Bruce C. Cotton[1] and Gail Hill[1];([1]AGSO; [2]GISolutions)*;
2. 28(ii). Australia's maritime boundaries information system (AMBIS), *Bill Hirst (AUSLIG)*

28. The Australian Spatial Data Infrastructure (ASDI) and the Geocentric Datum of Australia (GDA); *Steve Blake & Kelly Zammit (AUSLIG)*

Information management and decision making: is too much information ever enough?

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The primary purpose of information management is, at least in theory, to ensure that the right ingredients for decision making are available when required. It is a cyclical process that starts with identifying the questions for which answers are required and the information needed to answer those questions. The second stage is to collect that information. The third stage is to organise, analyse, assess and interpret that information. The final stage is to communicate the answers and the decisions reached. This is the classic 'intelligence cycle' of direction, collection, collation and dissemination.

There appears, however, to be an unwritten law that the higher up the corporate or institutional ladder one climbs, the less information one should seek because of the constraints it places on 'independent' decision making. In describing what he terms the 'brain-force economy', the American futurist Alvin Toffler observed in an interview published in *Wired* (November, 1993):

> *If you have the right knowledge, you can substitute it for all the other factors of production. You reduce the amount of labor, capital, energy, raw materials, and space you need in the warehouse. So knowledge is not only a factor of production, it is the factor of production. And none of the powers that be, in Washington and in the industrial centres of our country, seem yet to fully comprehend it. It scares them. It's threatening.*

It is probably this fear of information that has led many organisations to see information management simply in terms of what brand of computer and database software will be used and who will control them, i.e to restrict it to a narrow segment of the 'collation' phase. This approach invariably places control of the information management process in the hands of information technologists, rather than information managers - it is forgotten that information management pre-dates the computer by tens of thousands of years! Meanwhile, the decision makers have insulated themselves against the information they should be using so that they can more comfortably indulge in their favourite pastime - information-free decision making.

This paper focuses on the role of spatial systems such as GIS in the information management and decision making process. It has a particular emphasis on their application in a public safety environment. In this environment, poor decisions can and do cost lives, significant economic loss and substantial political outrage. It is an environment in which effective information management is literally a matter of life and death. It is also an environment in which too much information hardly ever seems enough!

Information management and decision making: is too much information ever enough?

Ken Granger

The primary purpose of information management is to ensure that the right ingredients for decision making are available when required.

This is not always appreciated because of three key factors:

- information is frequently undervalued;
- ‘information management’ is typically confused with ‘information technology management’; and,
- decision makers, especially those at senior levels, are afraid of information.

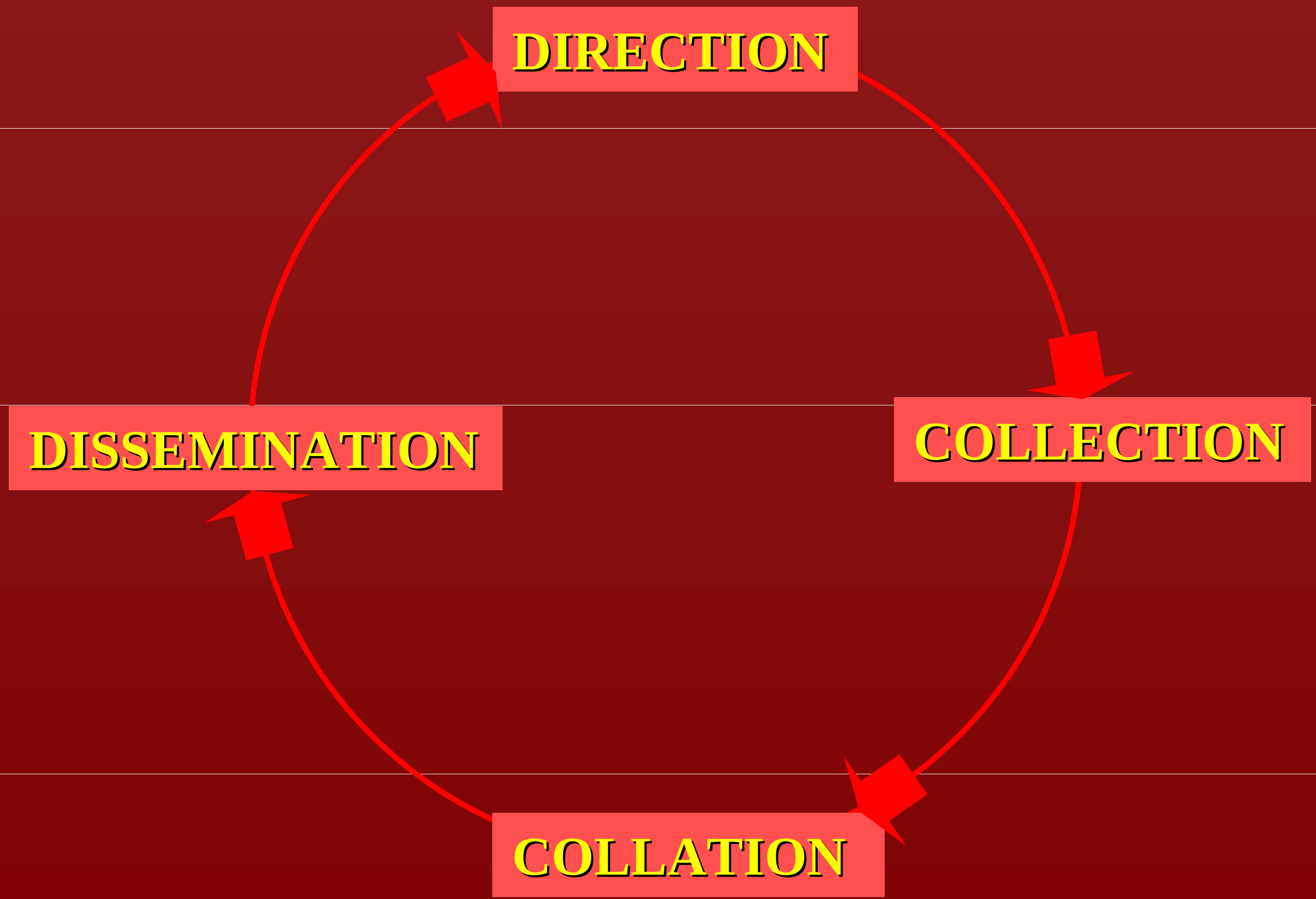
If you have the right knowledge, you can substitute it for all the other factors of production. You reduce the amount of labor, capital, energy, raw materials, and space you need in the warehouse. So knowledge is not only a factor of production, it is the factor of production…..

…And none of the powers that be, in Washington and in the industrial centers of our country, seem yet to fully comprehend it. It scares them. It's threatening.

Alvin Toffler 1993

Information-free decision making is, consequently, a very common practice, largely because of an inadequate understanding of information management.

The ‘Intelligence Cycle’



Direction

- what questions do I need answers to?
- what priority do the answers have?
- what information do I need to answer those questions?
- what is the time frame?
- who needs to know?
- etc, etc.

Collection

- what sources are available?
- how accurate and curr ent is the information?
- how can I get it?
- how much will it cost?
- do I need to collect it from scratch?
- how will I collect it?
- etc, etc.

Collation

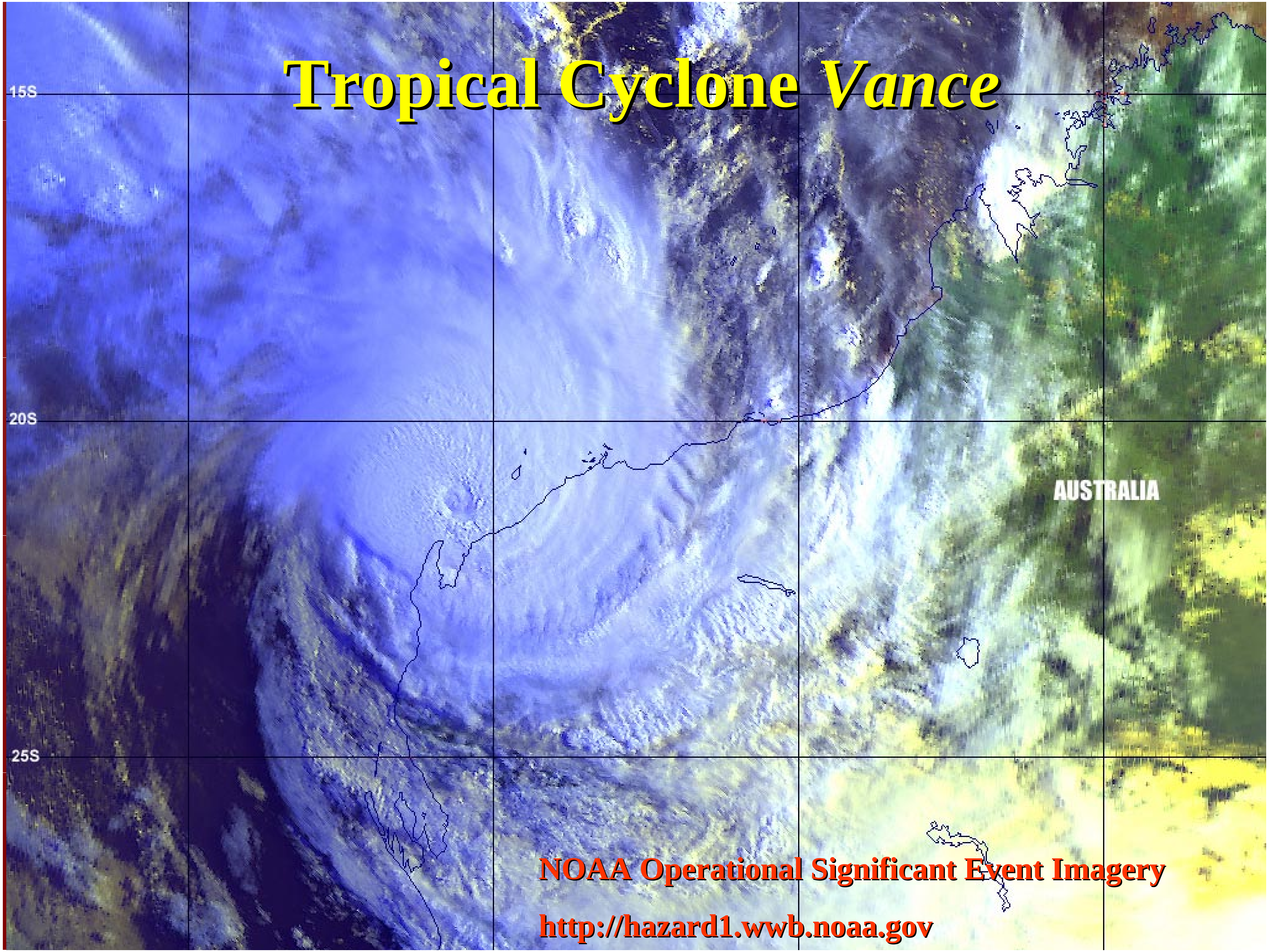
- how do I store it?
- how do I convert it to my format?
- can I combine it with other information?
- how should I analyse and interpret it?
- in what form will I provide the output?
- etc, etc.

Dissemination

- who needs to know?
- how do I communicate the information?
- do I need a communication strategy?
- what medium will I use?
- etc, etc.

A real world example of how it can work.

On 11 February 1999 Cyclone *Rona* crossed the coast to the north of Cairns leading to major flooding in the Barron River.

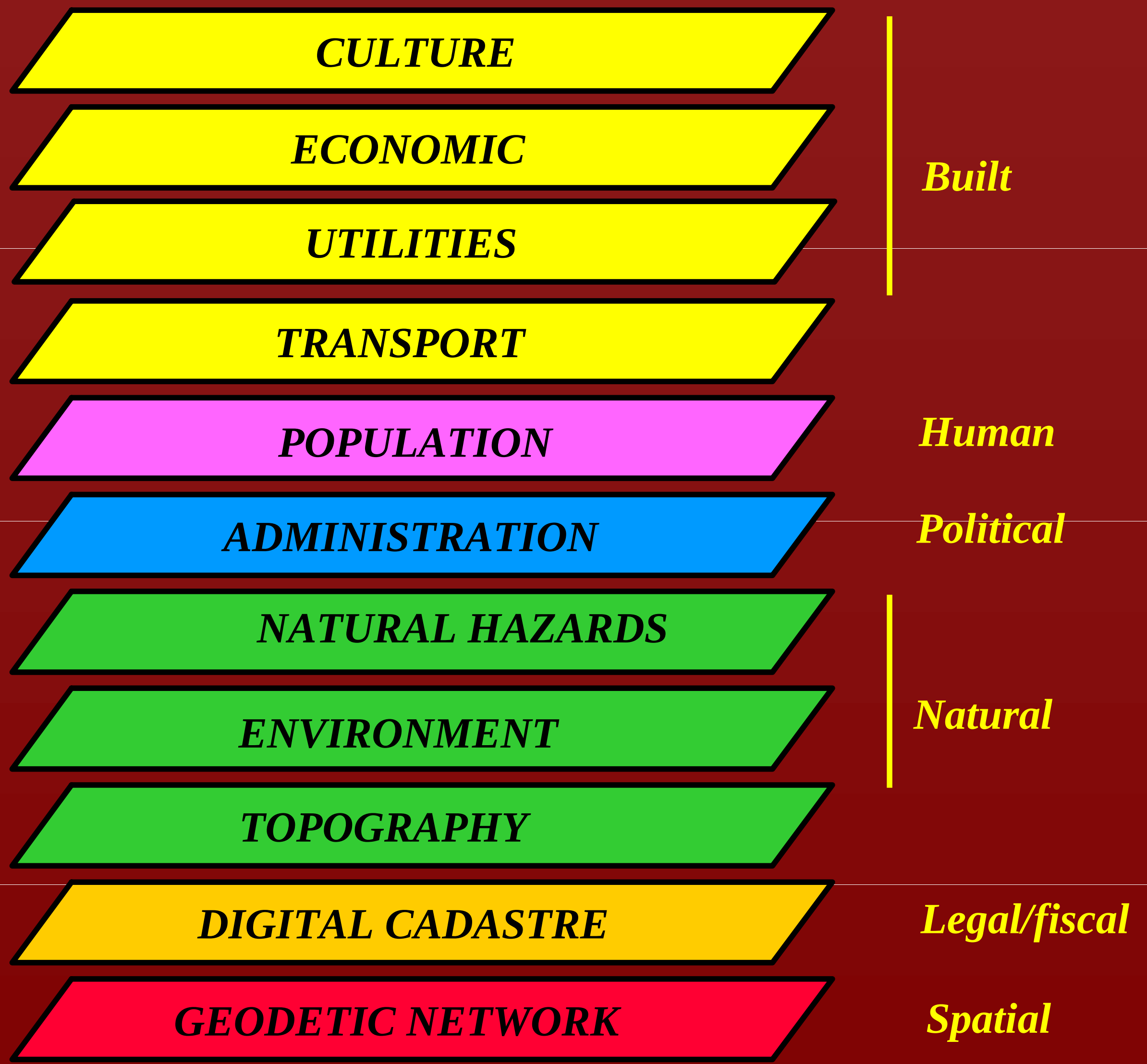

Tropical Cyclone *Vance*
15S
20S
25S
AUSTRALIA
NOAA Operational Significant Event Imagery
http://hazard1.wwb.noaa.gov

A hallmark of many ignorant people is their unflinching confidence that they possess perfect knowledge. Likewise, truly deep knowledge may bring with it a sober cautiousness about issues that most people regard as settled, and a wider appreciation of how much remains unknown.

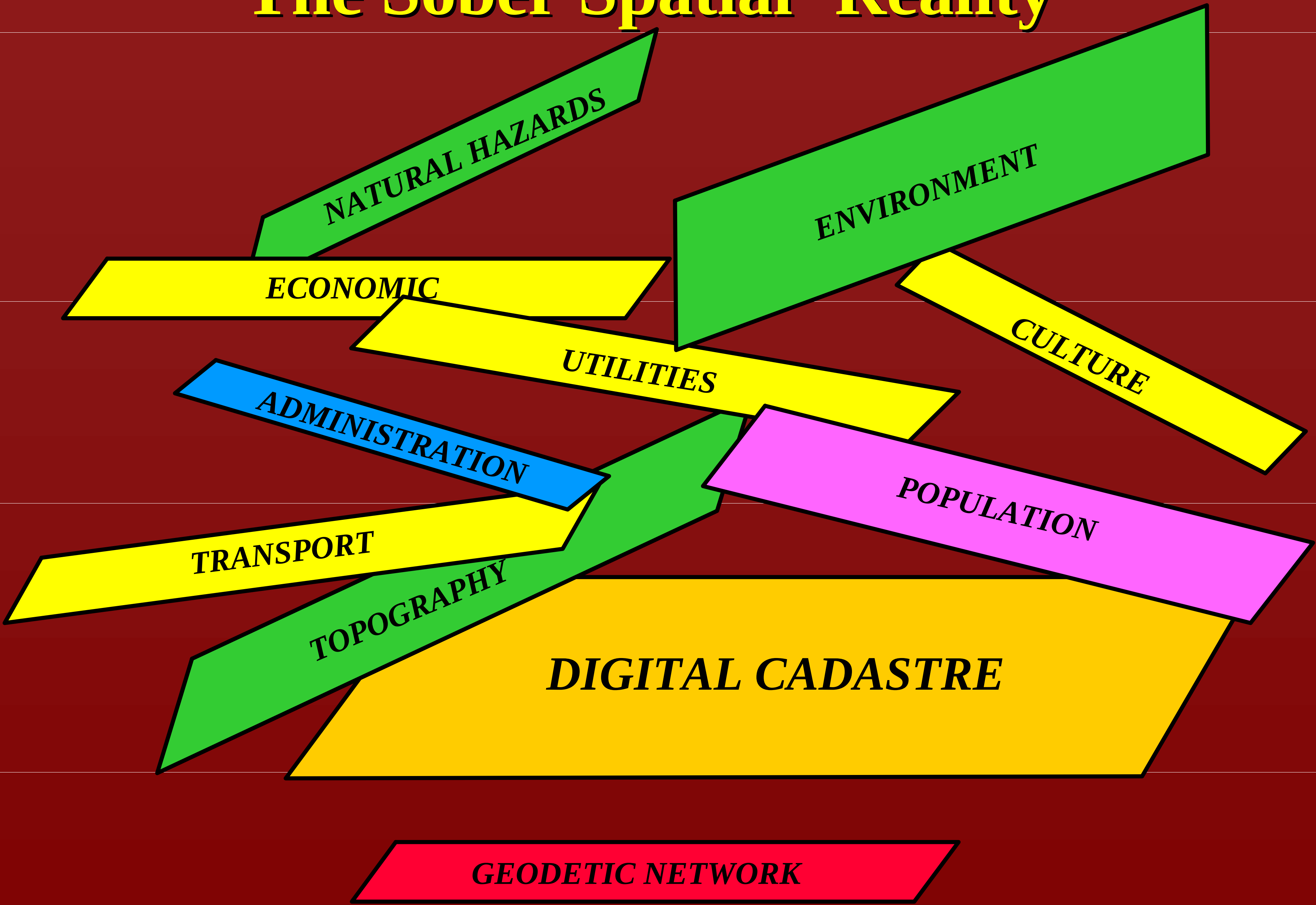
J.P. Reser & M.J. Smithson

Under circumstance like Cyclone *Rona*, the closer we can get to 'perfect knowledge' the better will be the outcomes.

Perfect Spatial Knowledge

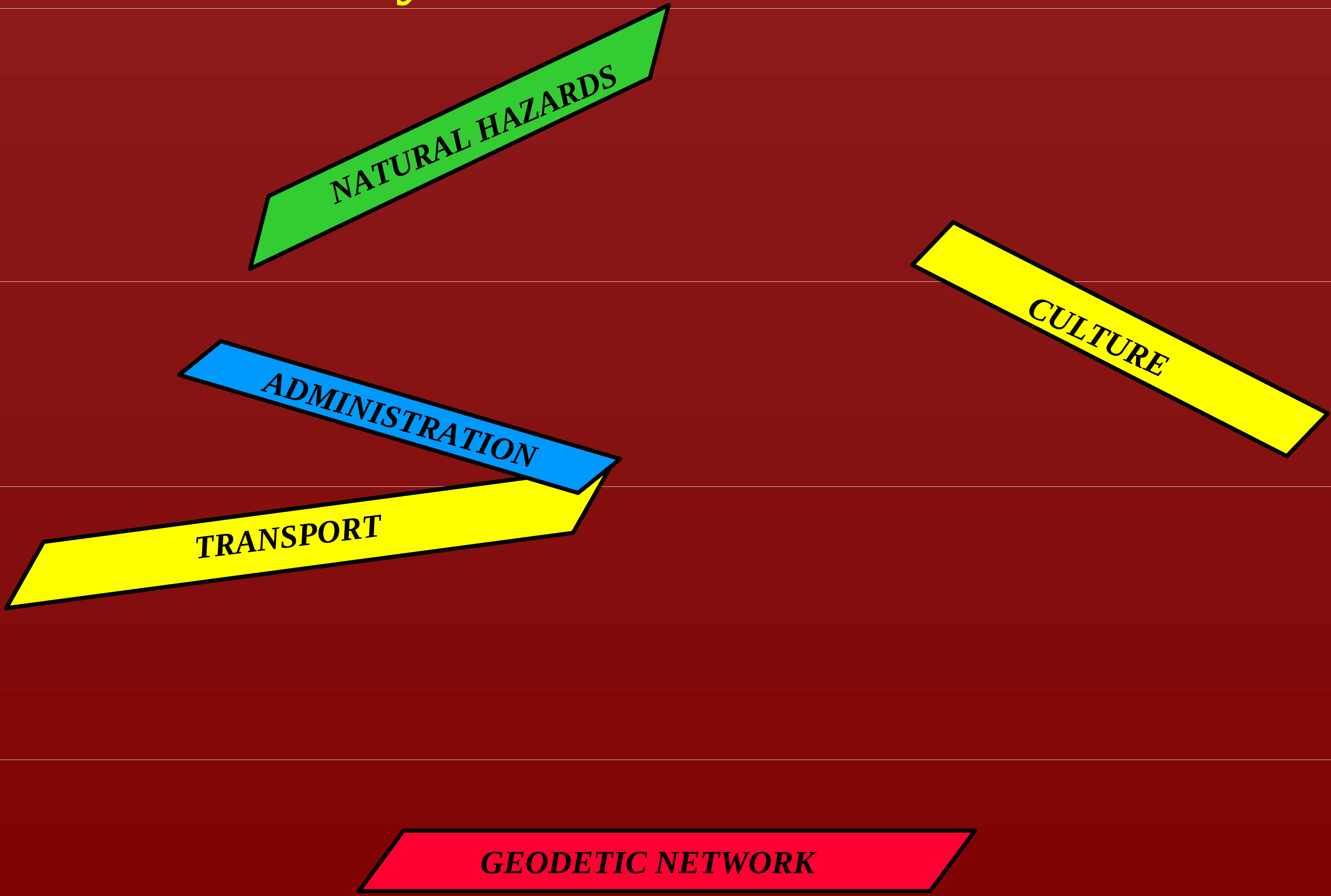


The Sober Spatial 'Reality'



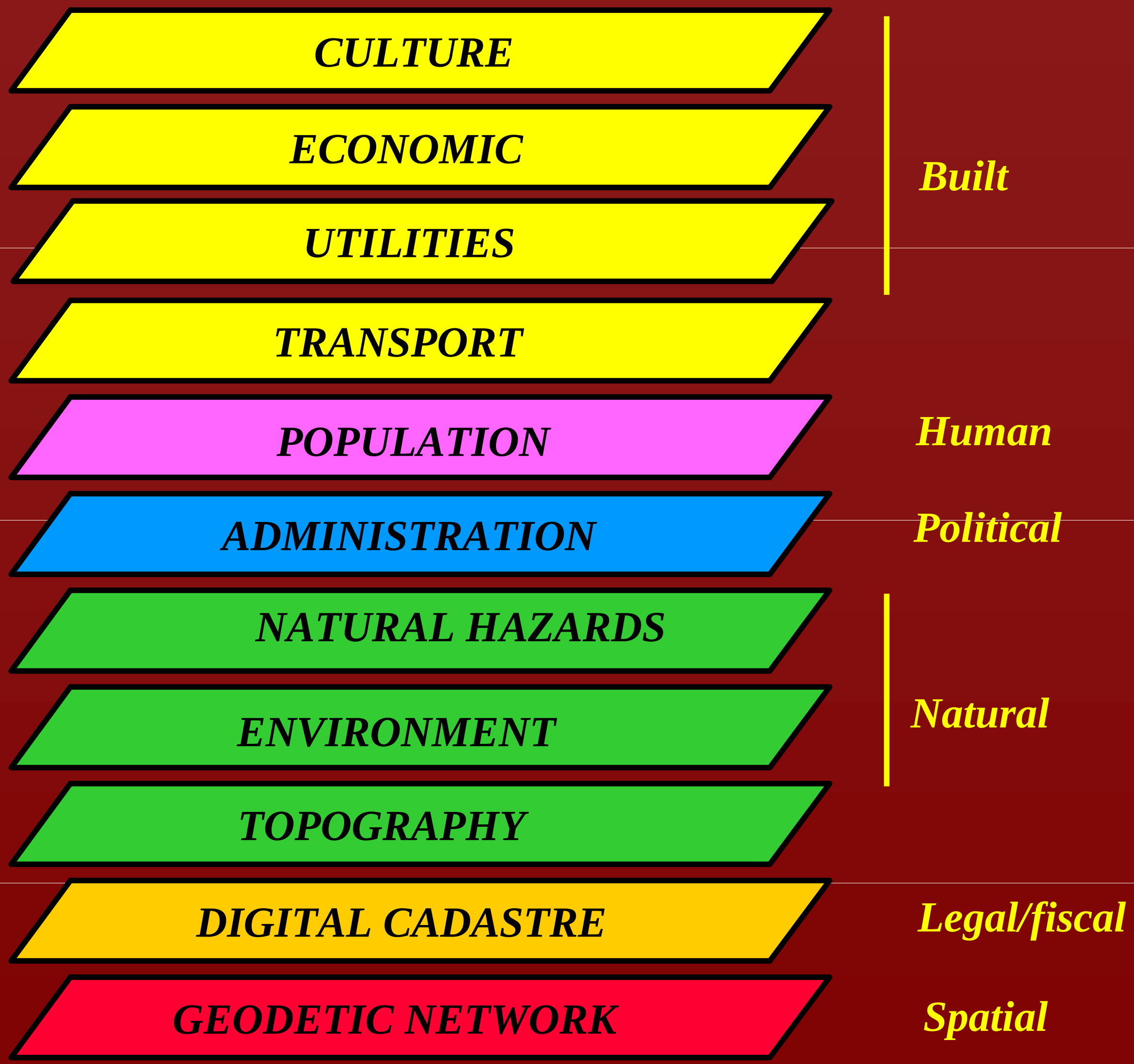
about A deep ignorant Likewise they , people remains unflinching confidence that possess cautiousness knowledge sober knowledge. it truly may of many bring with a that most people regard as settled, and a wider of how much unknown. is their perfect issues hallmark appreciation

In reality much remains unknown



*A hallmark of many ignorant people is their unflinching confidence that they possess perfect knowledge. Likewise, **truly** deep knowledge may bring with it a **sober** cautiousness about issues that most **people** regard as settled, and a wider appreciation of how much **remain**s **unknown.***

Perfect Spatial Knowledge



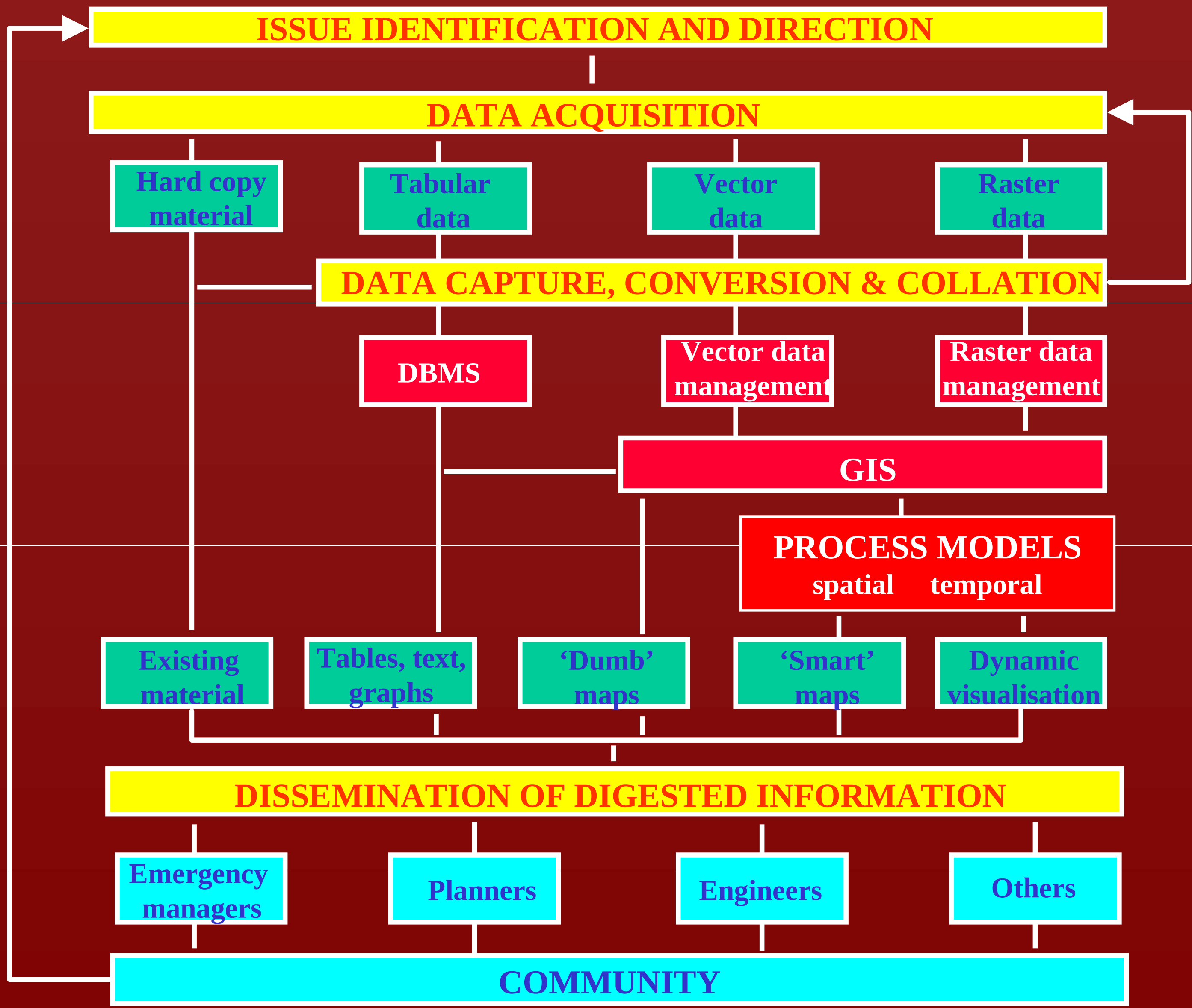
To get to this point we need an effective information management regime….

…and to have effective information management we need an appropriate information infrastructure.

An effective information infrastructure will include:

- an information culture
- an institutional framework
- a suite of technical standards
- the fundamental datasets
- a clearinghouse network
- competent, committed & cooperative people

Risk-GIS: an Information Infrastructure



Information management is too important to leave to information technicians, it must involve the decision makers, i.e. the people who USE the information.

Now white man got learning

He got university school.

He can read.

But me only read little bit.

White people got computer,

but Aboriginal, me…

I just write in cave.

Bill Neidjie

Papers

Fourth National Forum
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New South Wales Department of Mineral Resources: Report on information management and GIS developments

Peter Lewis, Program Manager, Discovery 2000 (Minerals)
David Kenny, Assistant Director, Information Systems

Update

In the period since the last conference the DMR has followed the path outlined in a strategic plan adopted in 1992 and modified in 1994. Funding for the current project work was secured in 1994. A major part of this plan involved the progressive move to central repositories for the major work program areas and their datasets. To bring this about the head office network was upgraded and most regional offices connected by ISDN lines. Several major projects were defined and contracted out. They are summarised below.

TAS—The updating of the Titles Administration Systems involving the transfer of existing business functions to an application platform integrating Oracle forms and ArcView GIS functionality, customised by Avenue code. To optimise the operation ESRI's SDE (Spatial Database Engine) and Oracle were chosen as the core to the system. The contract began in 1997 and will be finished shortly.

COMET—The acronym stands for a Common Mining Environment, a text (non-spatial) office management system for the Mines Inspection Branch using the Oracle DBMS, forms and common web browsers. It is designed to allow inspectors access to current datasets and documentation at the desktop and in the field. The primary use is in tracking safety and other urgent issues. The contract started in 1997 and will finish shortly.

COGENT—A 'Common Geological Environment'. The development of an information system for the Geological Survey. The contract is completed and is described in separate papers within this document. The development was based on the Oracle-SDE platform set up for TAS and has included production of a Web-based application providing access to primary datasets and metadata. A further development still being implemented is a revision of mapping practices to take advantage of the new system of data management and GIS functionality.

RECFIND—Remodeling of the Records Management System. A management and query application.

Other proposed projects include an upgrade of the Finance Branch systems and conversion of Royalty Branch to data-modeled management system.

DIGS—Digital Imaging of the GS Records (Exploration reports and related Departmental records). This project is being carried out as part of the Discovery 2000 Exploration Initiative. It is described in detail in a separate paper within this document. The reader is referred to that paper for more details. The project is ongoing and scanning of the GS Records as digital files should be completed this year. The system is in operation at head office and can be accessed by some regional offices. A contract has been concluded to provide regional offfices with an on-line access to DIGS using web-based technology. Note that a metadata enquiry system (Minfinder) is currently available on the Internet.

Intranet – Internet Issues

The Department has an *Intranet* application using standard browsers to give access to an ever increasing number of functions. The sites are in a state of flux and improvements in browser functionality are adopted with enthusiasm as the staff involved improve their skill levels.

The Department established an *Internet* site during 1997, but did not do much development of this facility until late 1998. The project work for DIGS and COGENT highlighted the need for new policy on Intranet-Internet issues. This new policy was released in 1998 and establishes guidelines for screen design and updating the site. The Department is also required to meet State guidelines encompassing a ‘whole of government’ approach. However the establishment of a network of interdepartmental hubs is still in its early stages. A number of projects aimed at establishing links between sites have been forwarded to the Office of Information Technology by a mix of ‘natural resource agencies’.

As a custodian of datasets on natural resources information the DMR will need to deal with the issue of providing *metadata* to State and Federal agencies. On-line Internet access to *primary* datasets whilst possibly feasible is not being considered at present. Before this can be done the Department needs to address the problems of data security, confidentiality, ecommerce and quality control.

Work Practices and Data Quality

The remodeling of the data tables in the Geological Survey has allowed standards to be set for authority tables. As an example, in the COGENT system the uploading of data into Oracle triggers an error report which is emailed to the custodian and the data administrator. The custodians have the responsibility for checking the data and making the necessary changes. Over time this self- imposed quality control will clean up the most obvious errors in the data. Data modeling of spatial data for shapefiles and ArcInfo coverages has been established for ‘corporate spatial datasets’. This will enable greater use of the SDE. The ultimate goal being a Statewide coverage of all spatial data with sensible ‘views’ across map boundaries.

The regional mapping teams and cartographers are expected to adopt new methods of data capture and processing. The Department has established three main layers of data management, a *data coordinator* overseeing data issues at the Department level, *data managers* for the major work groups such as the Geological Survey and *custodians* of Statewide datasets.

New guidelines have recently been established requiring all corporate data for capture or sale to have an ANZLIC compliant metadata statement attached.

Change Management—Training

Change management is a growing challenge for the Department. Despite the relative maturity of information management there is still a need for training in ‘basic’ functionality for many staff. Data model concepts are still a mystery akin to the black arts to the majority. Compounding this is the almost continuous change in software-hardware enhancements or new functionality.

A partial solution to the problem of hardware and software upgrades is a progressive move to leasing and greater uniformity in equipment and software. This will assist in establishing more effective training schedules for staff.

GIS Update/Trends

a) The Discovery 2000 Exploration Initiative will continue until June 2000 and multi-theme GIS packages will be produced for the project areas tackled by this program. The current projects (1998-1999) cover the Cobar-Nymagee area and a section along the Peel Fault north of Tamworth.
   A new Statewide dataset, being assembled at present, is a summary exploration borehole database called *Intersect*. This database has links to the DIGS data and will allow fast retrieval of logs, location diagrams and assay data.
b) The move producing packages of the map layers comprising standard series geological mapping continues.
c) New geological and stratotectonic maps of the State have been assembled as GIS products as well as hard copy.
d) GIS products continue to be a major input to the RCAC-CRA (Forest Agreement) Process. This seems to be an emerging trend and an attempt to speed up negotiation procedures between industry-State-Federal bodies.
e) The Geological Survey is revising its policy on products and pricing. It will increase its number of maps plotted on-demand and for some jobs will move to four colour print runs.
f) The major restriction to the growth of digital and GIS product development is the limit on available staff and resources. Budget cuts may require that most GIS products be restricted to the core activities, with less product development and little if any customisation.
g) The long term plans for product development will centre on the goal of acquiring a Statewide set of data based on a common datamodel. This will allow for ad hoc purchases (cookie-cuts) of data.

A review of GIS-based developments at the Queensland Department of Mines and Energy

Paul Garrad, Glenn Simpson & John Tuttle
Queensland Department of Mines and Energy

Abstract

Definite progress is being made in the application of GIS within the Queensland Department of Mines and Energy's (QDME) Geological Survey Office (GSO). GIS based initiatives are also being introduced to projects within the Resource Development Division (RDD).

GSO now has a more explicitly defined, information driven strategic role of developing and promoting the prospectivity and exploration potential of Queensland. The framework to pursue this role is well established in the form of:

- A spatial geoscience data resource (GRDB) and ready access to all relevant GIS structured digital data sets.
- Ongoing spatial geoscientific data capture with particular emphasis on the range of data attributes together with a new focus on information generation.
- A focus on data validation and data standards with attention to data quality - accuracy, consistency and relevance to intended use.
- The allocation of a separate computing environment for GIS based project development.
- Client surveys and the development of exploration industry focused marketing and promotional plans.

Current progress is demonstrated by:

- The use of GIS by project geologists to compile, validate and manage relevant spatial data.
- The development of promotional GIS packages and anticipated release of GIS format data packages.
- The development of quantitative mineral potential and prospectivity analysis in a GIS framework.
- Proposals for the delivery of information to internal and external clients via web map browsers.
- A proposal to deliver geophysical images to internal and external clients via a web based interface.
- Research into more efficient data storage and management environments including the development of a project proposal for digital company reporting.

Introduction

The role of GIS technology within the Queensland Department of Mines and Energy (QDME) has diversified over the past two years. This review highlights the progress achieved as a result of the introduction of PC based GIS software and user expertise to the Geological Survey Office (GSO) along with a new, more flexible development environment in parallel with the securely structured, MERLIN corporate environment. These changes have been the catalyst for a range of GIS based initiatives with application driven outcomes.

The focus has shifted from confining GIS use to digital map compilation and production areas to including routine interrogation of data within the new development environment. This has translated into flexibility, with the individual user able to retrieve spatial data for visualisation and analysis, and generate spatial information, independent of corporate system constraints but still governed by a management framework.

As GIS software usage and experience levels have broadened so to has the application potential, a factor increasingly recognised by senior management. The challenge now is to translate this potential into a user framework that recognises the full application potential of GIS technology and spatial information along with the spatial information requirements of client groups.

The current state and development trends of that user framework are the basis of the following discussion.

The operating environment

GSO has established a sound GIS foundation over the past two years, investigating its application potential for core activities and clients. GSO is responsible for QDME's geoscience programs, in contrast to the exploration and development issues relating to tenure management, resource project development, native title and land use, as managed by Resource Development Division (RDD). The two responsibilities share common outcomes and have now been more closely aligned with GSO having a more explicitly defined, geoscience information driven strategic role of developing and promoting the prospectivity and exploration potential of Queensland.

The Current GIS Environment

GSO's current GIS activities owe much to:

- The setting up of a specific GIS project development environment.
- The introduction of ArcView and MapInfo software.
- Digital geoscience data assets – a legacy of QDME's earlier development of the GRDB module of MERLIN

Together these initiatives have given project geologists the opportunity to:

- Visualise, verify and analyse spatial geological data.
- Develop structured GIS project data sets.
- Respond to ad hoc requests such as land use assessment in an efficient manner.
- Experiment with quantitative resource assessment and mineral prospectivity modelling.

The project GIS environment is a development framework designed for GSO and RDD project activities consisting of network delivered GIS software and an 8 Gb disk on a Unix server networked to individual user PC's.

Administrative and data custodial responsibilities including access and data read/write privileges have been set up to maintain environment integrity. Operating procedures have also been developed for data storage emphasising standardised directory and file naming conventions and minimal data duplication. The operating procedures have clear data management strategies in mind in creating a framework that encourages users to apply GIS tools to their data in an organised fashion as well as setting the parameters for data projects to be migrated to the product development process at a later stage.

Data Framework

Geological data is stored in Oracle tables in the Geoscience and Resources Database (GRDB); digital geological maps are compiled and archived in a structured GIS format capable of being migrated to desktop GIS systems. GRDB is a single database model structured as a series of systems – Surface

Geology, Boreholes, Seismic Surveys, Aerial Geophysical Surveys (AGSS), Codes and Parameters and Bibliographic References.

Surface Geology is the key system for GSO and RDD's GIS activities and stores geological, mineral occurrence and geochemical data all linked by the Sites and Locations tables. Users extract data from GRDB Systems either via Oracle Browser or direct ODBC links through Access or ArcView then map the point features as themes in the relevant GIS system.

Digital geological maps are supplied either as master ARC/INFO coverages or shapefiles coded with polygon and line features keys that link to Surface Geology system data. While basic feature attributes are supplied in lookup tables, the feature key allows the range of attributes to be expanded through the data extract pathways to Surface Geology. Any tenure and land use related data sets are extracted directly from the MERLIN graphics interface via a customised export routine.

These corporate data framework guarantee users have access to the most up to date spatial data sets for project compilation and analysis.

GIS-related developments

This emphasis is reflected in:

- GIS use by project geologists for the validation phase of field data and map compilation.
- The creation of GIS project data sets, the development of promotional GIS packages based on ArcExplorer and the anticipated release of GIS format data packages.
- Research into more effective data management environments.
- Trialing of web based map browser technology as an intranet/internet data viewing strategy.
- Resource assessment and mineral prospectivity analysis in a GIS framework

Data validation

The validation of field and map compilation data will benefit significantly from the use of ArcView software. Project geologists now interactively visualise field data rather than dealing with spreadsheets or hard copy map plots, applying spatially based checks and directing corrections back to the digital map compilation process or relevant Oracle data tables. ArcView is also routinely used to verify geological interpretations against the digital map compilation process as geological feature nomenclature is developed and loaded to the Surface Geology tables.

Project GIS Data Sets

The ability to develop compilation GIS data sets has been one of the main outcomes of the present GIS framework. The primary emphasis in GSO is on building master project or region based data sets complimentary to the major mapping programs that are capable of delivering a range of outputs. To date advanced GIS projects have been developed for the Hodgkinson Province and Southeast Queensland Region; the Yarrol, South Connors and Mt Isa projects will be the next in line (Figure 1).

The regional GIS projects contain a range of geological and land use related themes underpinned by rigorously compiled digital geology with the emphasis on building a single seamless map at field compilation resolution. This map is supported by the addition of a large range of feature attributes to introduce multi theme capability to the underlying primary geology. Developing a single seamless geological map has proven to be a challenging process but the benefits are reflected in analytical capability, and consistent geological nomenclature throughout the geographic extent of a project area.

The Hodgkinson and Southeast Queensland projects are currently being prepared for product development and they will be the forerunners of a new range of promotional and information packages aimed at land use and resource assessment and highlighting the exploration potential of Queensland. Marketing and promotional strategies are being developed to maximise the flexibility and impact of these compilation GIS databases.

The ability to build ad hoc data projects is also catered for in the overall GIS framework. The Northwest Mineral Province has been recently designated a priority region for promotion and in response to this a promotional data package has been compiled using the ArcExplorer browser. Land use decision-making is also a major priority and once again the current GIS and data framework cater for this contingency. This includes the development of new strategic data layers for the corporate system such as the recently completed coal resources layer for Queensland (Figure 2).

The Digital Company Report Project

The first steps have been taken for migrating the company report system for mineral and coal to one that is more relevant to today's technology driven environment. A project proposal has been developed that is expected to allow companies to lodge their exploration reports in digital form, with the Department able to verify, process, catalogue and store, as well as retrieve and supply them in digital form. The project is also expected to achieve agreement on data standards for company reporting in Queensland, which consider the AMIRA Geoscience Data Model and the modified GGIPAC National Guidelines for the Submission of Mineral Exploration Reports on paper and in digital formats. The system will satisfy client needs for a spatially and textually searchable report collection and is proposed to operate in the following manner.

Clients accessing the system will be able to view a menu on the Internet/Intranet and select the type of search they wish to make. They will then be taken either to a textual or spatial search engine that will retrieve the requested information from a warehouse of open-file data that will be updated at regular intervals from the storage system. The user will select the appropriate reports using these searches and will then be able to retrieve an image of the company report via the document management system. If the information required is too large to download then the user will be prompted to request the relevant information on digital media or in hardcopy format.

The system will allow QDME to be more competitive for exploration investment, contribute to the preservation of the company report collection and act as a catalyst for upgrading information technology and management in the Department.

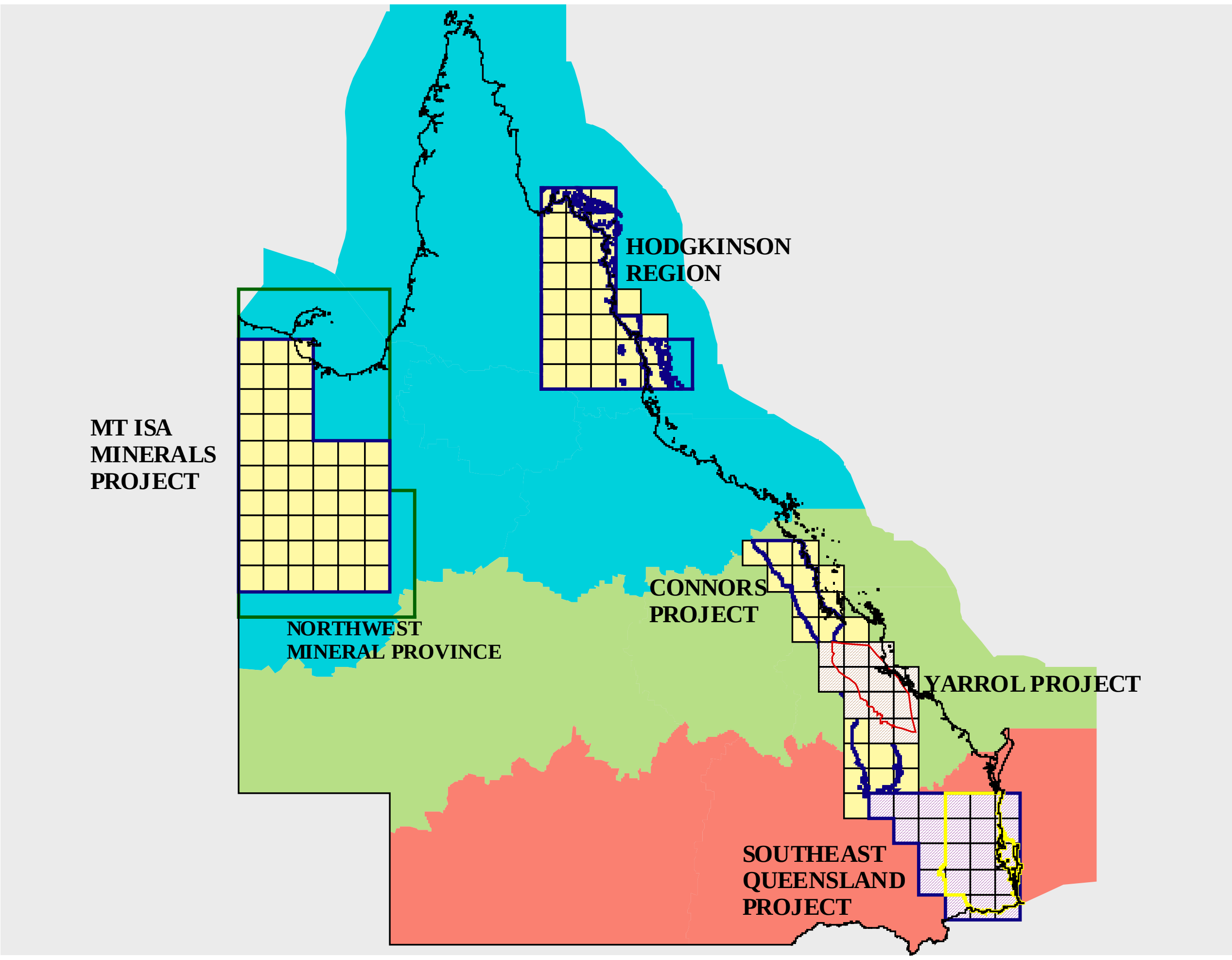

Figure 1 Location of Geological Survey Mapping Project Areas

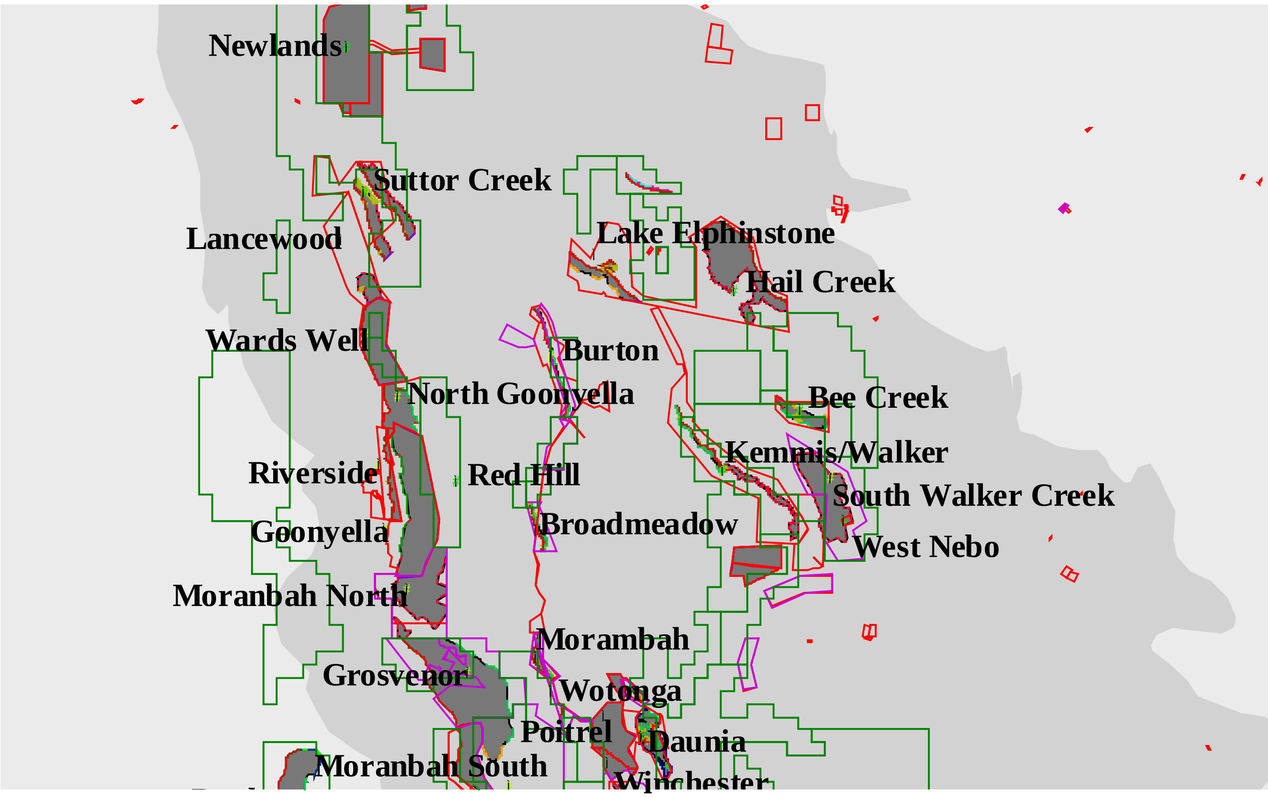

Figure 2 Distribution of Coal Resources and Associated Exploration and Mining Tenures North of Moranbah in Central Queensland.

The Queensland Mineral Resources Database (QMIN) Project

The QMIN system will manage the information requirements of the QDME relating to mineral deposit resource information, commodity data and general economic statistics. QMIN will assist RDD to respond to internal information demands and also help in attracting companies to explore and invest in Queensland.

QMIN has the following objectives:

- Development of a user friendly, interactive, output focussed database and management interface to provide accurate, up to date and client focussed data; and
- Increased client awareness of the mineral resources and investment potential of Queensland's mining industry.

The system will focus on viewing and updating information associated with current, economically significant mineral resources that are either being mined or have the potential to be developed. It will provide RDD with improved advice on mineral sector activities and ensure that competing land use decisions are made with the full knowledge of current operations and the State's mineral potential.

QMIN will utilise existing data infrastructure and introduce new technological initiatives (Figure 3). The implementation phase has three main components that are being progressed in parallel:

1. Enhancement of existing Oracle GRDB systems and creation of new data structures where necessary.
2. Development of a user-friendly interface.
3. Compilation of attribute and spatial resource information into the relevant GRDB Systems.

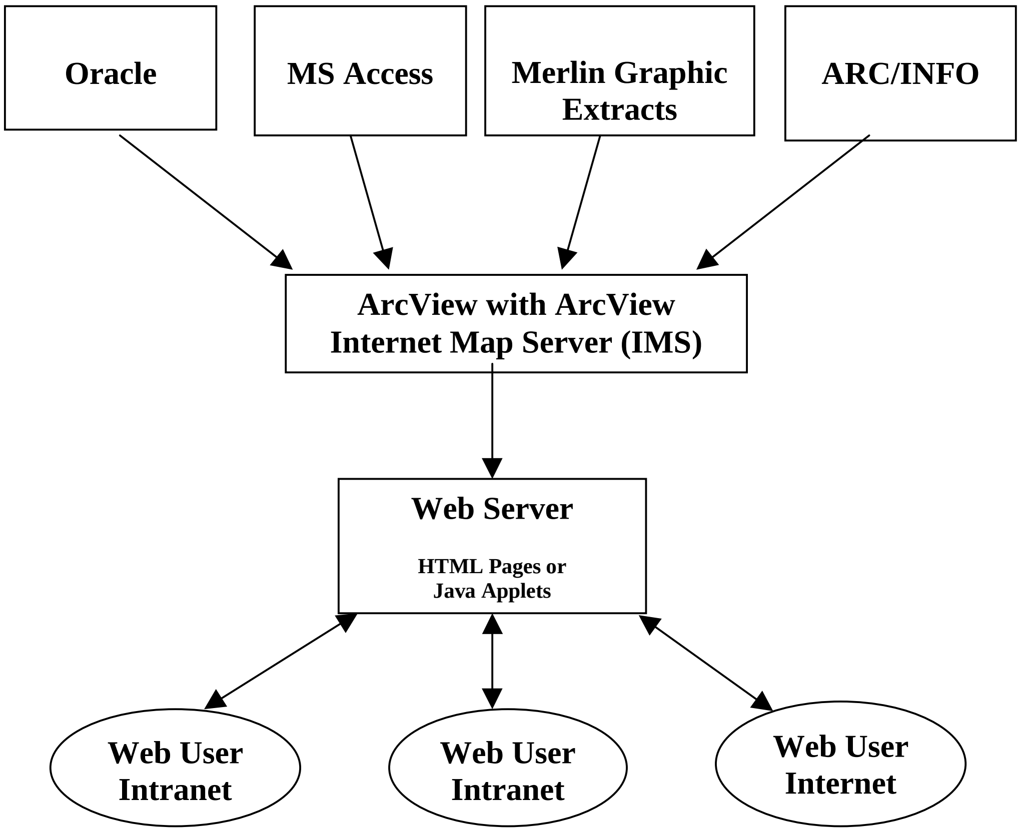

Figure 3 Diagrammatic Model of the Proposed QMIN Data and Software Operation.

Significantly, QMIN will take advantage of established data storage environments and current GIS technology, as the majority of the source data is associated with spatial entities. ArcView will be the primary software vehicle for compiling generic or specific data projects directly from the relevant databases, the project GIS environment and MERLIN graphics. However to meet the requirements of distributing this information to clients via a user-friendly interface, the web has been chosen as the ideal medium. This intranet/internet distribution mode will be pilot tested using ESRI's ArcView Internet Map Server (IMS) extension as the first choice. Providing it meets the performance criteria, IMS will be an ideal solution as it is consistent with the QDME's corporate GIS software environment

It is planned to have the initial QMIN system generate three main outputs:

- Internet/intranet data views for browsing and general level decision making
- Report Views of the data
- Digital data for distribution as GIS format files.

IMS Proof of Concept

The decision by the QMIN project to use the web as the ideal medium for displaying and distributing its spatial information has had a flow on effect to the whole concept of GIS related data distribution for GSO. In order to advance the web based option a 'Proof of Concept' project has been initiated using ArcView IMS in an intranet setting. The aims are:-

- To test the performance of the software in QDME's IT environment using QDME data.
- Determine if the performance/response rate is acceptable with QDME data.
- Determine the ease of use of the software along with its capability for customising functionality.

The assessment project is up and running and will be reviewed in early April. The successful implementation of web based mapping will have ramifications for the way QDME currently conducts much of it spatial information business and it is hoped that this move will lay the groundwork for the implementation of a range of information management tools.

Mineral Prospectivity Assessments

GSO has recently commenced adapting a methodology using quantitative resource assessment and mineral prospectivity modelling to meet the requirements for promoting Queensland's exploration potential. This type of analysis is receiving a high priority as a logical extension to GSO's mineral and geological mapping roles and will be made easier through the substantial volume of current digital data and the established GIS environment. However, it has been realised that there are certain data shortfalls that must be addressed and these are being factored back into the mapping and data gathering projects. The current development progress of our methodology will be addressed in another forum paper.

In conclusion

QDME's earlier investment in a unified corporate approach to spatial and attribute data capture and storage is now returning additional dividends as GIS technology is more widely implemented. The benefits of promoting the potential of GIS related technology at all levels of management and a more dynamic data user environment are reflected in:

- The development of new product types.
- The implementation of new data management and delivery strategies.
- The development of relevant, promotional and marketing strategies for targeting the exploration and mining industry.
- The ability to respond to requests for specific or ad hoc data projects.

The new GIS development environment together with a growing appreciation of the technology's applicability to project data management have also highlighted opportunities for evolving GRDB Systems. The current data exchange environment is far more dynamic as the emphasis shifts from data accumulation to data mining encouraging users to review the efficacy of the current data model.

Staff training and an emphasis on the rationale behind applying GIS tools have also become important issues in engendering widespread acceptance and use of new information delivery interfaces as management tools. The next stage will focus on building additional functional systems into the GIS and Oracle database environments that enable QDME to take maximum advantage of the intranet/internet as an information delivery strategy.

Information management and GIS in the Geological Survey of Western Australia — a review and future directions

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Abstract
In the past, the Geological Survey of Western Australia (GSWA) has taken a project-based approach to the capture and management of and access to its corporate geoscientific information. However, current and future expectations of clients both within and without GSWA have necessitated a rethink of how GSWA is to deliver greater access to a greater range of existing data.

Consequently, GSWA believes it must take a more corporate approach in order to bring together and integrate its GIS, cartographic, relational databases and other information systems under the umbrella of an enterprise-wide geoscientific information system. GSWA believes this initiative will provide significant advantages to itself and its clients.

Dissemination of GSWA's data holdings to the exploration industry and other clients has always been and will continue to be a high priority. GSWA is continually striving to improve the process and is looking closely at the rapidly evolving technologies, including the World Wide Web, to accomplish this aim.

Introduction
Since the early 1990's the Geological Survey of Western Australia (GSWA) has invested in a range of sophisticated database, Geographical Information System (GIS) and computer-assisted map-production (CAMP) software. To date these have been used purely as cartographic or map-production tools. The capacity of the software to store, analyse and model diverse geological data has been largely ignored.

GSWA has used a project-based approach in implementing CAMP and GIS within the organization since the early 1990's. While this has undoubtedly proved successful, there have been some recognized disadvantages, especially in relation to the sharing of data and the relative lack of associated attribute data.

As a result of several new mapping initiatives, there has been, during the same period, a large growth in the amount of field-based digital data collected and stored in GSWA's corporate relational databases. These databases are being implemented within the context of an overall corporate logical data model using the Oracle RDBMS.

To date, within GSWA, there has not been the symbiosis between the spatial and relational databases commonly seen in other mapping organizations.

Initiatives at GSWA since the Third National Forum on GIS in the Geosciences have centred on the need to increase the production of high-quality geological maps from existing cartographic and GIS databases. However, in the future GSWA will concentrate on developing an enterprise-wide, fully integrated, geoscientific, spatial information system in which all corporate spatial and attribute data are seamlessly integrated using the intelligent geological map paradigm. Users will then be able to take a unified view of the corporate data resources and thereby benefit from the synergism such an information system provides.

Recent Initiatives

GIS

Since 1994 GSWA has been using GIS for the storage of its geological map data. With an emphasis on project based GIS, series geological maps were only converted from the DGN format used in the map production area as and when needed. More recently there has been a program in place to convert the data to GIS format soon after the map has been printed and published. Presently there are fifty-nine 1:100 000-scale, twelve 1:250 000-scale geological maps and numerous maps from reports and bulletins in full GIS format. A series of twelve 1:250 000-scale regolith geochemical atlases, each comprising some 50 or so maps, has also been produced entirely within the GIS environment. One atlas received “Best Geoscientific Map” at the Mapping Sciences Institute of Australia’s Mapping Excellence Awards in 1998.

In 1997, GSWA purchased ArcView Internet Map Server (AVIMS). The development of an Intranet environment within GSWA has enabled geoscientists to access various map indexes, dataset themes and geological maps from their desktop. In December 1998, GSWA’s first AVIMS application was released to the general public via the WA Department of Minerals and Energy’s (DME) home page. The application is MAGIX, a spatial index to geophysical images covering Western Australia. Work continues on developing further applications for the Internet.

In June 1998 GSWA released the first of a series of Mineral Occurrence and Exploration Potential data packages. These packages comprise a report, a litho-printed map and a CD containing selected themes and images for the study area in several GIS formats (E00, SHP, MID/MIF). A customized version of ArcExplorer (developed by ESRI Australia) is also included on the CD to allow data to be viewed and interrogated directly from the CD. The front-end viewing application developed for these products will be used in future product releases. The Mineral Occurrence and Exploration Potential data packages received a “Highly Commended” at the Mapping Sciences Institute of Australia’s Mapping Excellence Awards in 1998 and was a finalist in the WA Premier’s Awards for 1998.

In 1997 GSWA commenced the creation of a seamless geological GIS database for the Eastern Goldfields of WA covering some one hundred and ninety-four 1:100 000-scale map sheets. As at December 1998, 15 map sheets have been incorporated into a seamless mosaic. Work is currently underway to develop a legend-generating tool in ArcView that will display those legend elements that match the map selected. In this way on-demand maps that ignore conventional map boundaries can be produced from the seamless database and provided over-the-counter to clients.

Computer-assisted map production
The primary digital map production tool in GSWA is the MicroStation suite of products. GSWA has an unparalleled depth of experience in producing geoscientific maps of a high cartographic quality using this technology. MicroStation was chosen because it was, and still is, recognized as the leader in professional computer-aided mapping and design software and known for it's excellent drafting, design, and visualization capabilities.

The MicroStation suite of products is used in all facets of the production of the 1:100 000- and 1:250 000-scale geological map series.

Multi-coloured litho-printing is still seen by GSWA as the preferred option for the production of its high cartographic-quality series geological maps. GSWA currently uses two map production processes. For highly complex, multi-coloured series geological maps Intergraph Map Publisher (Windows-NT version) is GSWA's preferred map finishing system. Less complex products capable of being produced by the four-colour process are processed within CADscript. However, CADscript as an alternative map-finishing tool is continually being upgraded to cope with more complex maps.

For first edition products for which multi-coloured litho-printing is not required because of the low production volumes (<100), an HP 2500 (600 DPI) plotter is used.

An automated colouring process using map labels has recently been developed and is being applied successfully to digitized compilations. This has significantly eliminated many of the colouring errors to which the previous process was prone and has thereby increased the efficiency and quality of the map checking process. The increased efficiency has been accomplished by the development of a colour-design database in MSAccess. Data from this database can be downloaded directly to Intergraph Map Publisher allowing automation of specification files for colouring, patterning and overprinting in the Intergraph Map Publishing software.

While much of the capture of digital data is achieved by hand digitizing geological map-compilation sheets, the digital capture of compilations suitable for scanning is increasing. Scanning offers GSWA significant reductions in time and improved quality assurance in the capture process.

Databases
Throughout its history GSWA has been collecting data on the geology of WA. Several recent initiatives have led to a large growth in the amount of data collected and stored in digital form. As a result of past and the more recent mapping initiatives, a large data holding exits within GSWA. However, these data are spread across a number of disparate databases most of which reside on different computer systems and even as analogue card systems.

In the past, decisions about the choice of data processing software were driven largely by specific and immediate needs without significant regard to data sharing, networking and data integration. Data sharing and data integration are now seen as important issues, as is the need to maximize the use of costly data in order to benefit from the value adding that data integration can bring.

With this in mind GSWA has embarked on the development of a series of databases within a single logical enterprise model and physical data structure. Initially the corporate database schema has been implemented in Microsoft Access97 in a networked environment. A Microsoft Access application front-end has been developed to allow geoscientists to enter data into and query the databases.

A number of databases have been developed as modules within the corporate schema. Where practicable the data models for the individual databases have been based on those of the corresponding AGSO database models. For example, the first two databases to be developed, WAROX and WAMIN, are based on the OZROX (Ryburn et al 1995) and OZMIN (Ewers and Ryburn, 1993 and 1994) models respectively.

More recently, other databases have been developed and are gradually being incorporated into the corporate schema. These include:

1. A palaeontological database that is being developed from a need to update the fossil registers that hold all relevant palaeontological data;
2. A regolith mapping database for data collected during the regolith and geochemical mapping program;
3. A geochemistry database for GSWA's regolith and whole-rock geochemical data;
4. A geochronology database for age determination data;
5. A petrographical database for storing data and information relating to thin sections;
6. A database to assist with the organization and management of GSWA's Carlisle laboratory facility.

Feedback on the ease of use and efficiency of these databases is continually being received from users. Consequently, modifications and improvements to the databases are ongoing.

In early 1999, following extensive development and testing, the WAROX and WAMIN databases were transferred to GSWA's corporate Oracle8 relational database management system. Users of the database throughout GSWA will continue to use the existing Microsoft Access application front-end to connect to Oracle.

Management of mineral exploration data

In WA DME has responsibility for the management of petroleum and mineral exploration data submitted under State and Commonwealth legislation. Within DME GSWA is the custodian of these data, which are maintained by two primary data management systems — WAPEX for petroleum data and WAMEX for minerals data. These data management systems have not kept up with changing technologies or with the current requirements of DME or industry.

DME recognizes that it is important that these data should be made more accessible to industry. With that in mind DME commissioned a firm of consultants to investigate current DME data management practices, to liaise with industry to find out what they require from WAPEX and WAMEX, and to make suggestions for improvement.

The consultants' report was submitted in December 1997. It recommended a three-phase implementation at a total cost of $8.3M of a new computing environment that would meet industry requirements for electronic submission, storage and distribution of data. It also recommended that the most important parts of the existing analogue data holdings should be transferred to digital media.

For a number of years DME has accepted statutory petroleum exploration digital data in a number of internationally recognized formats. Only recently has DME been accepting statutory mineral exploration data in digital format. This has essentially been on an ad hoc basis because until the advent of low-cost, desktop applications little mineral exploration data was available in digital format.

However, because more mineral exploration data are now being generated and stored in digital format industry is keen to submit the data in digital format rather than as hardcopy prints or plots from their databases. The corollary to the submission of data in digital format is that the data can be released back to the industry in digital format when they are released on open file. Industry can then include the open file data in their own databases and GIS systems for modelling and analysis.

Because DME wishes to accept digital mineral exploration data on a more formal basis than in the past, a set of guidelines (DME 1999) documenting the requirements in terms of acceptable media, file formats and metadata has been published. The requirements have evolved from consultation between industry groups and discussions with agencies in other States responsible for custodianship of statutory mineral exploration data. Although the submission of digital exploration data is not compulsory, DME started to formally accept digital data on 1 February 1999.

Future directions

A corporate, geoscientific, spatial information system

GSWA has realized for some time now that data held in its corporate RDBMS and cartographic databases, GIS datasets, and processed, remotely sensed imagery can be readily integrated. GSWA has also recognized the benefits to be gained from integrating its corporate datasets. If the existing digital map databases were fully integrated with geological map attribute data held within the corporate RDBMS, users could take a unified view of the corporate data resources and thereby benefit from the synergism such an information system would provide.

Integration of data within GSWA would not only bring distinct advantages in regard to data sharing but would also centralize the management of GSWA's data holdings as well as have a significant bearing on the future improvement of the map production-processes.

To take advantage of these benefits GSWA has embarked on the development of a fully integrated, user-friendly and effective digital, geoscientific, spatial-information system (GSIS). The GSIS being developed by GSWA comprises a series of fully integrated, digital, spatial- and map-attribute databases all logically linked to the existing corporate relational databases. The aim is to store in the GSIS not only the data from which the geological maps are constructed, but also to produce the maps themselves directly from the databases.

The GSIS will be developed using the intelligent geological map paradigm. In this context, intelligent geological maps are those digital geological-map products that can be produced directly from digital spatial and attribute databases in such a way that the data from which the maps are constructed are fully integrated with other multi-source digital geological data and information.

Because GSWA will produce its geological maps and digital data packages directly from the GSIS once it is established, there will be a number of improvements including:

1. Closer links between the information portrayed on the digital geological map and data and information held in other information systems;
2. Maps based on the very latest information;
3. Seamless geological maps.

Issues that GSWA will have to address and resolve that will have a significant impact on the development of the GSIS include:

1. Management of digital map data;
2. Empowerment of geoscientists to compile and compose geological maps in a digital environment;
3. Availability of all corporate data resources at all times to all users;
4. Integration of the CAMP and GIS map-production processes.

Fundamental to the development of GSWA's GSIS is the need to capitalize on the functionality provided by the corporate RDBMS. There are a number of options open to GSWA in this regard — dual (hybrid) databases, spatial data middleware, and extended RDBMS.

GSWA believes that the most robust solution is to extend the relational model of the RDBMS and thereby benefit from the in-built functionality of the RDBMS in terms of data integrity, performance optimization, database recovery, transaction support and so forth.

The GSIS will consist of three key pieces of technology. The first component, GSWA's corporate Oracle8 RDBMS, forms the foundation on which the rest of the system will be built. The second component, Oracle Spatial Cartridge, will provide storage and management of spatial data within GSWA's corporate RDBMS. The third component, Intergraph's GeoMedia Pro, is an integrating technology that will provide seamless integration of topical and legacy data currently held in a variety of different systems and will provide sophisticated map-compilation and composition capabilities.

Storage and management of image data

GSWA believes that a truly integrated GSIS should also include raster (image) data as well as point, vector and other map-related data. Point and vector data share many features and are therefore easily integrated. Raster data, however, are more difficult to integrate with point and vector data because of their innately different format.

Undoubtedly, the integration of raster image data within the GSIS data will provide significant benefits to the end user. The question that GSWA must address is how effectively it can integrate its massive raster data holdings into the mainstream of a corporate GSIS.

With modern-day relational databases like Oracle8, the problems associated with managing large objects (LOB) such as images have disappeared. These LOBs can now be managed by many RDBMSs and can be stored within the Oracle8 RDBMS as BLOBs or stored outside the Oracle8 RDBMS as BFILEs. Alternatively, the use of the interMedia data cartridge extension to Oracle8 may offer GSWA significant benefits to the storage and management of its image data.

3D modelling

The creation of 3D models from data held within the GSIS would aid the geoscientists' own understanding of the geology of an area, but is not a key requirement in the short-term. However, the creation of models is likely to become much more important in the future, as geoscientists become more familiar with digital modelling techniques. Consequently, the design of the GSIS will be structured to accommodate 3D modelling.

Using the extended relational model of GSWA's GSIS, it is possible to build into a logical data model a pseudo-3D component. This can be achieved by building into the model the ability to represent various geological surfaces on which the geology has been interpreted such as the topographic surface and regional unconformities.

Publishing maps on the World Wide Web

The ever increasing demand, both from within and without GSWA, for increased access to GSWA's corporate data holdings has encouraged GSWA to work towards allowing users full-scale access to these data via Web applications. The approach of delivering spatial data combined with an integrated spatial-information system to an end user through the WWW is not new. Essentially two approaches prevail in the delivery of spatial data — static maps and dynamic or interactive maps.

GSWA's aim is to allow users to interact dynamically with live map data held in the corporate spatial and attribute databases. Hyperlinks between documents will ensure that the most current data available in related databases is posted during a session, thus preventing out-of-date data from being viewed.

Web-enabling the corporate databases

As part of an ongoing review of its existing front-end data entry and query applications to the corporate Oracle databases such as WAROX and WAMIN, GSWA expects to replace the existing Microsoft Access front-end within the next year or so. Several options are available but the most promising appears to be web-enabling through the use of such application development tools as Oracle WebToGo and Oracle8i Lite.

Applications developed with these tools allow users to interface with the corporate databases through standard Web browsers and allow them to browse all the objects in the database for which they have permission, query and update rows as well as execute stored procedures. The development and deployment of these types of applications and the administration and configuration of the Oracle RDBMS are also made easy by tools such as WebToGo and Oracle8i Lite

Mobile computing

Within the near future GSWA will examine in detail a proposal to enter the field of mobile computing for its field geoscientists. Mobile computing allows users to have a subset of the corporate database reside locally on a mobile computer whether PC, laptop or palmtop. Mobile users such as field survey geoscientists are then able to access corporate information anytime, even when offline. This means that the corporate databases can be replicated on the mobile computer, the geoscientist can interact with them when in the field, update data in the local databases, and then replicate those data in the corporate databases on an as-and-when required basis.

In this regard GSWA will research the benefits of using tools such as Personal Oracle Lite and Oracle8i Lite which are Oracle's object-relational DBMS for mobile users. These products are fully compatible with Oracle8, and can provide the flexibility needed by users such as "nomadic" field geoscientists, and hence is able to form the foundation for distributed applications. It provides all the data replication functionality necessary to permit mobile users to have the most up-to-date data on their laptops.

It is anticipated that the mobile computing applications developed by GSWA will contain a high degree of "Web enablement" through the use of development tools such as Oracle WebToGo and Oracle8i Lite.

Spatial data warehouse

Little has been written about the need for the warehousing of spatial data and the tools and technologies that provide the solution. However, Milton (1997) has reviewed the situation in Western Australia and has prompted the Western Australian land-information community to consider early adoption of spatial-data warehousing as an integral part of its service to the wider community.

The development of the GSIS based on Oracle8 RDBMS and Oracle Spatial Cartridge will give GSWA the technical ability to develop a spatial-data warehouse. However, even with the technology in place, the organizational and political constraints and challenges to implementing a spatial-data warehouse still need to be properly identified and addressed. Fortunately, GSWA recognizes the need to incorporate a warehousing component in its strategic plans for the delivery of data and information into the next century.

Summary

Over the past few years the amount of digital data acquired or created by GSWA has grown significantly. There is every reason to believe that this growth will continue for the foreseeable future. The storage and maintenance of these data have been and will continue to be a high priority within GSWA. At the forefront of efforts to bring all GSWA's digital data holdings into a corporate environment is the development of an integrated GSIS. Hand-in-hand with this development is the development of more user-friendly data entry and query tools and applications to access the constituent databases.

With the development of a GSIS comes the ability for increased sharing of the data it contains both within and outside the organization. In this regard the development of web-based applications and web-enabling of the corporate databases is seen by GSWA as particularly important.

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GIS initiatives in Victoria

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Minerals and Petroleum Victoria (MPV) has continued to improve its GIS capability since the last GIS Forum in 1997. This has been largely due to the continuation of the Victorian Initiative for Minerals and Petroleum (VIMP) program.

VIMP 2001
The VIMP program has already invested $18.5 million in the collection of new geoscientific information since it was launched in 1994. With a further $7 million extension of the program over 3 years to June 2001, VIMP 2001 will continue to provide further impetus to acquire quality data. The main components of the program are:

- Geophysics – industry standard airborne magnetics and radiometrics surveys. Airborne surveys currently underway in the onshore Otway Basin, offshore Gippsland Basin and Warburton 1:250 000 mapsheet areas will increase survey coverage to over 90% of the State. In addition, over 60% of the State has been covered by closely spaced gravity data;
- Geological mapping – continuation of the production of new generation 1:50 000 scale geological maps, concentrating on areas of strategic Palaeozoic outcrop;
- Geological databases –mineral deposit, heavy mineral sand boreholes, exploration geochemistry and petroleum data compilations;
- Drilling – ground truthing bedrock geophysical interpretations under cover of Murray Basin sediments.

Clients are increasingly using GIS as the preferred tool to view, interpret and analyse these and other data sets. MPV supports two GIS platforms.

Corporate GIS
The corporate GIS, called GINGER, runs using *Genamap* software linked to an *Ingres* database within a *Unix* environment. GINGER is primarily an online Display Query system for over the counter tenement enquires at head office as well as regional offices. Only limited querying and display variations are permitted and output is restricted to preset formatted hardcopy text or fixed scale plans. Themes available include:
- Tenements – current and expired exploration, mining and extractive industry licences updated daily;
- Geophysics – magnetic, radiometric, gravity and digital terrain model colour images derived from 200 m grids;
- Geology – statewide 1:250 000 scale geology;
- Boreholes – mainly groundwater bore information;
- Mineral deposits – historical and current mines as well as significant exploration prospects with attached scanned plans (13 000 sites covering 70% of the Palaeozoic outcrop area);
- Land use – National Parks, reserved and unreserved Crown Land, etc;
- Cultural features – roads, towns, rivers, contours and mapsheet boundaries.

A small IT team is responsible for maintaining and developing the system.

The corporate GIS system has the following characteristics:
Advantages
- Real time data access – eg, tenement data updated on a daily basis;

- Archival security – corporate systems in place to ensure long term security of data;
- Standardisation – variety of data available in a consistent, uniform manner.

Disadvantages
- Limited access – Departmental offices only;
- Cost – high initial cost of development of new systems;
- Restricted output formats – digital data output is limited to unformatted ASCII text, hard copy reports are long winded and free format scale plots are unavailable.

Project GIS
The advent of relatively cheap PC based GIS and database systems has enabled the display and manipulation of data by your average geologists as well as your IT experts. Themes available include those listed in the corporate GIS as well as the following:
- Geophysics - magnetic, radiometric, gravity and digital terrain model colour images derived from 50 m grids (covering 70% of the State);
- Geology – 1:50 000 scale geology maps, including site specific structural data (covering 35% of the Palaeozoic outcrop);
- Geochemistry – all stream sediment and soil samples from expired Exploration Licences (360 000 samples covering 85% of the Palaeozoic outcrop);
- Heavy mineral sand boreholes – 11 000 boreholes from expired Exploration Licences in the Murray Basin.

A project based GIS has the following characteristics:
Advantages
- Increased access – both internal and external clients can use the data on their own PC and query and manipulate the data to their own specific project requirements;
- Variable output – client specific customised output available in various formats.

Disadvantages
- Data management - potential for new data to be managed at a project rather that corporate level, with possible variations in standards and limited access to project data by a wider audience;
- Security – long term security of data is tenuous when many people have access to the data, making several similar, but different copies of the same data set. Incorporation of project data into the corporate set should be seen as an integral part of the project, not as a last minute add on;
- No real time access – only a snapshot of the data is available, eg, tenements available on a monthly rather than real time basis.

Project GIS data sets are available cheaply on CD. The distribution of key data sets is presented in Figure 1 and shows a significant increase in available data over the last 2 years.

Land use planning
As well as mineral prospectivity and project generation work, geological GIS data sets are being used with planning data to aid land use planning decisions. Local municipal planning schemes have only recently been available in GIS format in Victoria. This has greatly assisted the sieve mapping process where geological, planning, environmental and social factors are assessed to assist with the development of municipal strategic planning schemes.

Future challenges
Many challenges face the management of information within MPV. These are similar to other geological institutions around the country and hopefully conferences such as this will assist in developing common solutions. Issues include:

- Data coverage - key data sets to cover strategic areas by June 2001;
- New GIS themes – additional key geological data such as mineral exploration drillholes digitally captured;
- Expanded corporate database – all data stored in the PC environment should be included in the corporate database, eg, exploration geochemistry and heavy mineral sands boreholes;
- Increase access – ensure data is available for viewing and access via the Internet, including online tenement information;
- Project data availability – project generated GIS data which is inputted directly into the corporate system is often not available to the PC users during the life of the project. This limits the ability of the project geologists to add value to the data;
- Digital Exploration Licence data – as part of an Australian wide scheme, ensure digital data in statutory Exploration Licence reports is submitted in an appropriate standard, is securely stored and available to clients in a readily useable format in a timely manner;
- *Genamap* migration – given the current vendor uncertainty, investigate alternatives to *Genamap* as a corporate GIS tool.

MPV is strongly committed to expanding and improving its GIS data sets. With continued VIMP funding, MPV will be able to provide statewide coverages of most key geological data sets in the near future – benefiting MPV project work and assisting industry to better target its exploration effort.

Managing exploration industry reports in the Northern Territory: projects and prospects

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Abstract

This paper presents a developmental history and project status report on the Northern Territory's Industry Reports Management System (IRMS), which was recently introduced for the better management, dissemination and preservation of company exploration reports. The IRMS project is currently focused mainly on the retrospective digital capture of existing reports and a major data cleansing and enhancement of the reports profile database. As the NT has recently moved to accept reports in digital formats, the ramifications of this move are examined. They include the immediate potential of Adobe's Page Description Format (PDF), the longer-term potential of the Standard Generalised Markup Language (SGML) standard and convergence of reporting guidelines at a national level. The project coincides with a period of major development and re-focusing of the Northern Territory Geological Survey.

The Industry Reports Management System (IRMS) Project

Since the early 1980's the Department has used flat file databases to manage company exploration reports and their associated parts. These databases have included core and sample management, digital data, and the reproduction of these reports for clients and for archival purposes. Reports received have for many years been indexed to a basic level by administrative staff before being passed to geologists for scientific assessment, more complete profiling and abstracting. After this process they are stored in "open" or "closed" repositories managed by the Geoscience Resource Section of the Information Services Branch. As it is common for a report to have many parts and attachments of a type that cannot be bound into it, report tracking is a time consuming and frustrating affair, made worse by secondary loans within project teams.

As a result of unsupervised data input over many years, DME's exploration report database had ended up with extremely dirty data in a largely unworkable database structure. When first the quality of the database was investigated, it was found that there were approximately 45 000 entries in the exploration reports database but only about 13 000 exploration reports held by the Department. Fewer than 30% of the record fields held data, and that data which had been entered was un-validated. Many fields contained input more appropriate to other fields: all were suspect. Various projects had been attempted over the last 10 years to address these issues - and a little over two years ago the Industry Reports Management System (IRMS) was given formal approval, and sufficient funding, by Management Board.

The goals of the IRMS projects include:

1. Improved report indexing,
2. Introducing improved workflow management of reports,
3. Digitally imaging or capturing all reports,
4. Publishing open file reports on the World Wide Web, and
5. Creating an environment suitable for receipt and management of digital reports.

Goal 1: Improved indexing

Database Migration

Both original databases, GeoReports and CoreRecords, had been developed on Titan software in the UNIX environment. A review of departmental information technology a few years ago resulted in the abandonment of the UNIX platform in favour of Windows. Most corporate databases were targeted for redevelopment on Oracle, often with an intermediate period running on MS Access. Because of the unstructured, textural, nature of abstract and other fields in the reports databases, the enormity and immediacy of the cleansing task and a desire to make reports available on the Web as quickly as possible, the decision was taken to use Inmagic's DB/TextWorks as the database platform. (DB/TextWorks has many natural advantages: it is well-priced, extremely user-friendly, customisable, excellently supported, robust, and very easy to interface with the Web.)

All data have been stripped from the Titan databases and migrated from to the new IRMS data structure on DB/TextWorks. All fields were cleansed either prior to or shortly after loading, an enormous task, and validation tables were developed and incorporated.

Validation and Cleansing

The validation exercise was vast, several of the files to be checked being of many megabytes. Validation has been the responsibility principally of the project manager and the reference geologist, who has also used her knowledge of the report collection and Territory geology to make sense of the export files. The majority of to-be-cleansed files were in excess of 1000 pages. MS Word and a number of UNIX utilities were used. Pareto's Principle was made manifest in this work, and the last-to-be-loaded or validated fields took much more effort to cleanse than their predecessors.

There were two main process involved in the cleansing of data. Firstly, for each technical field in the new database (eg. Tectonic Unit, Stratigraphic Names, Mines, Deposits, Wells etc.), a validation list was established using scientific or industry standard thesauri or lists. These lists were then loaded into the database, and an attempt made to load the corresponding fields from the old databases. All non-valid terms were rejected, creating exception files. These exception files were corrected and re-loading, a process which typically required several iterations. By the nature of their content, validation fields of this type continue to grow, thus creating an ongoing need for management. They might more appropriately be called authority lists.

Secondly, more stable validation tools were created as NT-specific data subsets (eg. Gazetteer, AMF Thesaurus, Stratigraphic Names, Map Sheets). These were loaded as immutable validation lists, and also made available on the DME Intranet with a view to improving the quality of indexing in future.

During these processes, the database structure was further refined, and new fields with more specific data subsets were added. As an example of this process, information about geochemical sampling was previously recorded in non-standard forms in various fields within the old database, but it has been coalesced into the dedicated field, Geochemical Sampling. Thus information has become more relevant and more easily retrieved.

Other technical, but free text, fields such as open and closed abstracts that cannot have validation lists associated with them have been re-visited to check accuracy, completeness and spelling. This has been the grandest task of all.

There are obvious advantages in having clean, validated data. It will enable the Department to participate on a national and international level for the first time, through contributions to, for example, the Australian Earth Science Information System (AESIS) database. While we have financially supported this project for years, we have contributed fewer than 25% of our report metadata - and that by re-keying by AMF staff! As AESIS has never been able to accept our data digitally, the NT is the most under-represented region in this National project. We expect to have contributed profile data for all open file mineral and petroleum exploration reports by the end of April 1999.

As the validation and loading phase draws to a close, the IRMS database contains almost16 000 exploration report profiles, with an increasing number of links to the 13000 core sample records and reports managed in a database.

Status	**Mineral Exploration Reports**	**Petroleum Exploration Reports**	**Geological Survey Reports**	**Total**
Open File	9197	1247	573	**11017**
Closed File	3976	394	340	**4710**
Total	**13173**	**1641**	**913**	**15727**

Goal 2: Workflow

Dedicated workflow software has not yet been purchased or systematically installed across the Department. However, workflow practices have been implemented through the IRMS project, using MS Outlook. This phase required a period of process modelling and re-engineering, an attempt to change some aspects of Departmental culture, an increased work load for some staff (we empowered them!)

There is now an accountable tracking procedure for industry reports from receipt in Records Section, through the various processing channels including Titles, the Geological Survey, Mines and Energy divisions, out to the imaging bureaux, and back to Geoscience Resources. Workflow also controls the out-sourced copying for clients and digital image management.

It has been estimated that the exploration report collection could be worth up to two billion dollars. As it is the largest collection of unstructured exploration data relating to the Northern Territory, it is essential that this resource be exploited fully. Workflow is enabling Survey staff to identify, in newly arrived reports, those appendices and tables which are relevant to the Department’s growing range of structured geoscience information databases. Closer association with the structured information resources being developed in or acquired by the Survey will enhance the value of both collections.

Goal 3: Digital imaging

A major and innovative component of IRMS is the ongoing imaging of exploration reports. This is the aspect of the project which offers most to industry clients. It is anticipated that it will take four years to complete the scanning of all extant reports. So far, about 100 CD-

ROMs (approximately 65 Gb) have been delivered. This image base represents somewhat more than 10% of the collection. This phase of the project can be expected to accelerate now that the database is stable, the profiles clean and workflow adequate for project needs.

The collection of CDs will shortly be written to a central server hard disk and linked to their database profiles. Clients will be able to view and download images of our exploration reports over the Web and print in colour, and at original size, if they have the compatible hardware. Hence it is a requirement of IRMS that it continues to be a standards-conforming project. Because of file size or equipment constraints, clients may prefer to e-mail Geoscience Resources to request copies of reports, on paper or digital media. The Department will continue to provide space for researching reports in hardcopy and digital formats.

The scanning phase of the project is introducing an added degree of sophistication. Adobe Capture software has been acquired for the implementation of optical character recognition (OCR) of report images. Stored originally as Tagged Image Files (TIFs), images will be converted into the Adobe Portable Document Format (PDF) for OCR. The resultant text stream will be indexed and dumped into a full text field in the profile database, a process made easier using Inmagic's Intranet Spider software. To facilitate this process, scanning resolution has been increased from 200 dpi to 300 dpi.

Goal 4: Web publishing
Inmagic's Web Publisher, PowerPack and Intranet Spider software products are installed on departmental servers, and the database is web enabled. Web menu, search and display forms have been developed, but will need further refinement before the IRMS product is officially launched. All images linked to a report profile will be available over the Web. Where digital reports are available, the text and table parts at least will be "launchable" from the web browser. Where files are too large or bandwidth too small, searchers will be able to choose to download compressed files or e-mail the Department requesting to report be copied and sent by post or courier service.

The IRMS web site is currently located in the departmental intranet test area, and will remain there until completion of the concurrent project for redeveloping the Northern Territory Department of Mines and Energy Internet site. The IRMS database will be accessed from URL http://www.dme.nt.gov.au/ntgs/dbtext.htm.

Goal 5: Digital reporting
As is has become clear that a major revolution in reporting is occurring, the exploration industry has increasingly requested permission to submit reports in digital formats. We are now on the cusp of digital reporting, and the publication *Exploration reporting and the submission of digital data* was circulated to Industry for comment in October 1998. This document can be downloaded from the Web at http://www.dme.nt.gov.au/ntgs/minrep_guide.htm. The Department has now embarked on a trial period in which we are accepting reports in digital format, constantly re-visiting our procedures and guidelines – and working with industry in an effort to make the trial as successful and painless as possible. This innovation will revolutionise the way reports are received, processed, assessed, stored, managed and published; and IRMS strategy and workflow have to be flexible enough to accommodate such changes.

A feature of the PowerPack software is its ability to manage remote input to the IRMS database. In preparation for this, a Report Metadata Form (Minerals) has been developed. It has been placed on the Web and is alluded to in current digital reporting guidelines. Companies are requested to print a copy and supply it along with their report, be it in digital format or on paper. Eventually this form will be redesigned as an HTML post action form and received by PowerPack. Companies could attach their digital report, perhaps zipped up as a single attachment to this form – and it could be assessed in an IRMS Receipt Database, before being transferred to the IRMS database proper. The Report Metadata Form (Minerals) can be found on the existing Web at URL *http://www.dme.nt.gov.au/ntgs/minrep.pdf*.

National Exploration Reporting Trends

Uniform guidelines

The move for a uniform national approach to mineral exploration reporting began at least a decade ago, was adopted by the Government Geologists Database (now Information) Policy Advisory Committee (GGIPAC), and has been gaining momentum over the last three or four years. This period was characterised initially by a period of mutual patch protection, but the predominant characteristics now are cooperation between the states and territories and a recognition that the guidelines must cater for digital reporting. The Northern Territory guidelines owe much to work done interstate, especially in New South Wales and Queensland. The NT guidelines have in turn, we hope, influenced others. At the recent GGIPAC meeting, there was a significant move towards production of a national approach to the management of digital reports, and recommendations for achieving this goal will go before the Chief Government Geologists in April or May.

Standard Generalised Markup Language (SGML)

There is considerable potential, subsequent to the adoption of uniform reporting protocols, for adopting the SGML standard for report creation, management and publication. This standard, *Information processing - Standard generalised markup language* (ISO 8879:1986), allows rich tagging of report or any other data based entirely on its structure. A characteristic of SGML is the creation of document frameworks called Document Type Definitions (DTDs), which map the nature of the relationships of all elements of a document, A particularly useful DTD has been designed by the US military for the management of tabular data: the so called CALS tables, or more precisely US military tables DTD (MIL-STD-37874 DTD).

In the Northern Territory, we have begun the development of a preliminary mineral exploration reporting document type definition, using Microstar Near&Far Design software. The philosophical underpinning of the DTD includes:

- An initial structure based upon a three-part report
  - Front matter, containing profile data of the type captured in the IRMS database and requested on the Report Metadata Form (Minerals)
  - Body, containing exploration summary and sections tagged according to the disciplines involved (geophysics, geochemistry, etc.)
  - End matter, containing bibliography, tables, images etc.
- State-related entity tables (maps, tectonic units, etc.)
- Attribute-managed controlled vocabulary lists (e.g. AMF thesaurus subsets)

SGML is characterised as “hard to understand” and is proving difficult to “sell”. Promoting the DTD approach is akin to trying to sell a car to someone who has never seen one but has seen tyre marks. A pilot SGML implementation would have to be relatively painless for company authors. The most palatable approach would be to develop an MS Word document template based upon the mineral reporting DTD and to make it widely available along with state entity tables and validation tools, perhaps as a CR-ROM package. Reports written with this template could be reconstituted as fully compliant SGML documents using Adobe FrameMaker +SGML 5.5 in each state geological survey. The report text or data could then be loaded into conformant databases. An additional advantage of this standardised approach would be the ability to deliver only the requested and relevant parts of reports which were retrieved by a client's search of the database. The adoption of a similar approach for the handling of tabular data would result in data ready for database import.

While it remains to be seen whether SGML will remain an elusive Holy Grail or become the *rexque futuris* of exploration reporting, it is predicted that within a decade all reports management will be based on this standard.

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Northern Territory Department of Mines and Energy

REPORT METADATA FORM

(MINERAL EXPLORATION)

PART A (DME USE ONLY)					
Report Number	Date Received				
Collation	___ pp.	___ figs	___ logs	___ maps	___ apps.
Media	___ CDs	___ 1.5"	___ Exab.	___ DLT	___ vols.

PART B			
Tenure Number(s)		Company Report Number	
Report Date		Anniversary Date	
Group Project Name			
Report Title			
Author(s)			
Corporate Author(s)			
Maps 1 : 250 000			
Maps 1 : 100 000			

Tectonic Units			
❑ Amadeus Basin	❑ Carpentaria Basin	❑ McArthur Basin	❑ Pine Creek Inlier
❑ Arafura Basin	❑ Daly Basin	❑ Money Shoal Basin	❑ Simpson Basin
❑ Arnhem Inlier	❑ Dunmarra Basin	❑ Murphy Inlier	❑ South Nicholson Basin
❑ Arunta Inlier	❑ Eromanga Basin	❑ Musgrave Block	❑ Tennant Creek Inlier
❑ Birrindudu Basin	❑ Fitzmaurice Mobile Zone	❑ Ngalia Basin	❑ Victoria Basin
❑ Bonaparte Basin	❑ Georgina Basin	❑ Ord Basin	❑ Warburton Basin
❑ Browse Basin	❑ Granites-Tanami Inlier	❑ Pedirka Basin	❑ Wiso Basin
Other structural units			

Stratigraphic Names			

AMF Thesaurus Terms - General			
❑ Geological mapping	❑ Regional Geology	❑ Stratigraphy	❑ Structural Geology
❑ Metallogenesis	❑ Remote sensing	❑ Imagery	❑ Landsat
❑ Petrology	❑ Lithology	❑ Literature reviews	❑ Metamorphism
❑ Lineaments	❑ Photogeology	❑ Reconnaissance	❑ Indicator minerals
Other terms ...			

AMF Thesaurus Terms - Target Minerals			
❑ Gold	❑ Silver	❑ Tin	❑ Diamonds
❑ Lead	❑ Copper	❑ Platinum Group Minerals	❑ Industrial Minerals
❑ Zinc	❑ Uranium	❑ Bauxite	
Others…			

AMF Thesaurus Terms - Mining			
❑ Environmental impact surveys	❑ Feasibility studies	❑ Geostatistics	❑ Metallurgy
❑ Ore reserves	❑ Resource assessment	❑ Mineral resources	❑ Mining geology

❑ Mine design	❑ Mine drainage	❑ Mine evaluation	❑ Pits
Other terms ...			

AMF Thesaurus Terms - Geophysical Surveys			
❑ Aerial magnetic surveys	❑ Aerial radioactivity surveys	❑ Aerial EM surveys	❑ Ground EM surveys
❑ Gravity surveys	❑ Geophysical anomalies	❑ Gravity anomalies	❑ Bouger anomaly maps
❑ Sirotem surveys	❑ Ground magnetic surveys	❑ IP surveys	❑ Resistivity surveys
❑ Seismic surveys	❑ Magnetic anomalies	❑ Geophysical interpretation	❑ Geophysical logs
Other terms ...			

AMF Thesaurus Terms - Geochemical Exploration – Surface sampling			
❑ Geochemical sampling	❑ Stream sediment sampling	❑ Rock chip sampling	❑ Bulk sampling
❑ Soil sampling	❑ Heavy mineral sampling	❑ Geochemical anomalies	❑ Assaying
❑ Isotope geochemistry	❑ Whole rock analysis	❑ X ray diffraction	❑ Sample location maps
Other terms ...			

AMF Thesaurus Terms - Geochemical Exploration - Drill sampling			
❑ Diamond drilling	❑ RAB drilling	❑ Percussion drilling	❑ Air drilling
❑ RC drilling	❑ Rotary drilling	❑ Vacuum drilling	❑ Auger drilling
❑ Drill core	❑ Drill cuttings	❑ Drill hole logs	❑ Drill core analysis
Other terms ...			

Drilling Type	**No. of holes**	**Hole name(s)**
Diamond		
Percussion		
Vacuum		
RAB		
Auger		
Air		
RC		
Rotary		
Other ...		

Mine / Deposit / Prospects		**Location - AMG**	**Location - Datum**
Mines			
Deposits			
Prospects			
Other …			

Northern Territory Department of Mines and Energy

Exploration Reporting and Submission of Digital Data

Contents

November 13 1998

1. Introduction

The Northern Territory Department of Mines and Energy will begin accepting mineral and petroleum exploration reports in digital format from 1 January 1999. This move is in response to the Department's wish to streamline geoscience information services, and is in accordance with industry requests for the introduction of this reporting format. Companies reporting on their exploration tenures are now encouraged to supply a digital copy of their reports in Adobe Portable Description Format (PDF).

Hard copy reports from companies detailing the results of work carried out on exploration tenures for minerals and petroleum will still be accepted during a change-over period which may extend to 31 December 2000. This two year trial period will give smaller companies time to make arrangements for digital reporting.

Further comments from members of the exploration industry are also welcomed, especialy in regard to the transitional period.

2. Exploration Reports

This section refers to the preparation of both <u>mineral</u> and <u>petroleum</u> exploration reports.

<u>2.1 Text or Summary</u>

Companies are currently using a variety of software programs to acquire and make sense of exploration data. A report will typically be a compilation of various file types, e.g., .doc, .txt, .cdr., ArcInfo, .xls, etc. Although these file types are useful for the purpose for which they were devised, they are not at present easily combined or concatenated to form a fully integrated report.

Different people, each with access to the same group files of representing a report, would most probably reconstruct different versions of that report. Moreover, the rationale for digital reporting is to make reported data more readily useable, but that presupposes both:

- That everyone has the required software applications to open each of these files, and
- That the ability to read these forms will continue to be available well into the future.

At present, while there is minimal knowledge of the Standard Generalised Markup Language (SGML: ISO 8879:1986) in the exploration industry, making sense of a digital report, and consistently reconstructing it, is an insurmountable challenge. Even though a Microsoft Word document can provide the main summary and textual interpretation, there is consistency neither of word processor brands nor of versions within a given brand. Without standards or limits, reconstructing the remainder of the report would be a nightmare.

From the beginning of 1999 the NT Department of Mines and Energy will accept either:

a. **A hardcopy report, with data appendices in a digital format conforming to Section 2 below, or**

b. **A "hardcopy equivalent" digital report, fully compiled, indexed etc. in Adobe Acrobat Portable Description Format (PDF) , with data appendices in a digital format conforming to Section 2 below.**

Each report should be in essence a summary of activity carried out during the reporting period together with a financial summary and a detailed listing of appendices. The list of appendices must include all data file names, file types and clear indications of the media types on which they will be found.

If option **2.1(a)** is chosen, the media which constitute the remainder of the report should be contained in an envelope or envelopes bound into the report. All envelopes should be clearly marked with the appropriate appendix number and the media should be marked with the contained file name(s). Note that option (a) above will negate the need to provide hardcopy appendices of geochemical data.

If option **2.1(b)** is chosen, all media files should be contained on an integrated package (ideally a CD-ROM) or in an envelope, sleeve or small box suitable for placing on library shelving. All envelopes etc. should be clearly marked with the appropriate appendix number and the media should be marked with the contained file name(s).

Henceforth, reports will need to be submitted with an accompanying *Report Metadata Form* (RMF). There are minerals and petroleum exploration reporting RMF proformas for the lodgement of returns (See attachment).

Note: Abobe PDF versions of RMF proformas will be downloadable from the DME Website and viewed using Acrobat Reader. (If you do not already have Acrobat Reader, a free copy may be downloaded from Adobe Systems Incorporated, at http://www.adobe.com/prodindex/adobe/readstep.html.

2.2 Graphics (plans, figures, photos, GIS, graphic logs etc.)

The inclusion of maps, plans, figures, photographs, GIS compilations etc. is still considered at integral part of the report and must be presented in hardcopy or "hardcopy equivalent". DME encourages the inclusion of digital copies of these graphics if available. Acceptable production formats include TIFF or JFIF (JPEG) for graphics and ArcView or MapInfo for GIS compilations, but the files should be converted to PDF format and associated with the text component.

The media containing the file(s) should be clearly marked with the contents. The file names and file formats should be listed in the report's contents section.

3. Treatment of Appendices

3.1 Data sets (drilling, geochemistry and ground geophysics)

In the past these were presented in hardcopy as pages of tabulated data, normally contained in an appendix to the report. *The Department now requires that such data be **included in digital form only**, replacing hardcopy*. Microsoft Excel97 is the currently preferred format but any commonly used IBM compatible spreadsheet formats may be accepted by arrangement with the Department. Delimited ASCII files are also acceptable. Note that each digital data set must be accompanied by a description of the data.

The digital data should be in standard ASCII format. Each set of data should comprise of the following:

- A summary file (*readme.txt* file or *header.txt*) that describes the data and identifies the files containing that data. All relevant information relating to all the data sets, e.g. codes, types of analyses, detection limits, type of drilling, drilling contractors, hole numbers, co-ordinates, logged by, date etc. should be documented. The Department would requires the use of meaningful file names (e.g. *EL1234_2000.txt*), or at least EL1234*_summary.tx*t (or EL1234*_summary1.txt*, EL1234*_summary2.txt* etc.) if multiple files are involved.

- One or more data files containing the data referred to in the summary file. Data should be space delimited, i.e. each column or field should be separated by a series of spaces such that all text columns are left justified and all numeric columns have their decimal points lining up (see Table 1). Column headings should be included, as the first row of data. These files should have meaningful names using *.dat* as the extension (e.g. *EL1234_2000_drill.dat*).

Table 1

Borehole	**Top**	**Base**	**Porosity**	**Permeability**
Afmeco Kun Anj DDH KUN001	1289.74	1347.56	0.34	12.45
NTGS Rosemary Tin Mine DDH3	12.56	15.67	2.50	8.67

If space delimiting is not possible or impractical, other delimiters *may* be acceptable. Contact DME for clarification.

3.2 Downhole Geophysics

Companies submitting downhole geophysical logs are encouraged to submit digital LAS (preferably Version 2.0) or ASCII files (pipe, comma, tab, space, semi-colon or colon delimited with column headings and units) *as well as hardcopy*. LAS format is preferred. There should be a separate file for each well. File names should be in the form "tenure_log1.las", "tenure_log2.las" or "wellname.las". A list of file names and disks should appear in the contents of the appropriate accompanying report.

The standards for LAS formats are available at nominal cost from:

CWLS
#229, 640 5th Avenue SW
Calgary, Alberta, T2P 0H6
CANADA

Tel: 0011 1 403 269 9366
Fax: 0015 1 403 269 2787

3.3 Airborne Geophysical Surveys

Geophysical data from airborne geophysical surveys (magnetics, radiometrics and electromagnetic) is required to be submitted within 6 months of completion of the survey in digital format acceptable to the Director of the Geological Survey. The data must be located and levelled, and in standard ASCII code. It should be presented in GDF or GDF2 format as specified by the Australian Society of Exploration Geophysicists.

3.4 Seismic Surveys

A comprehensive report is required for seismic surveys within six (6) months of completion of the survey. In line with a recent decision by ANZMEC, seismic sections (currently accepted as film or sepias) should also be submitted as CGM/CGM+ format graphic files. These files should be named with the line name followed by the ".*cgm*" extension (eg; KUL2001-05.cgm). This is in addition to submission of SEG-Y format tapes of the actual seismic data.

4. Digital Report Presentation and Submission

Reports must be submitted on time, in accordance with requirements of the grant of tenure, to the Department and addressed thus:

Department of Mines and Energy
Attention: Reference Geologist
GPO Box 2901
Darwin NT 0801

Reports may also be submitted in person to the reference desk in Information Services Branch (Library) on the 3rd floor of Centrepoint Building on the corner of Smith Street Mall and Knuckey Street, Darwin.

4.1 File names

Meaningful file names are required. For reports over a discrete area, the file name should be a composite of tenure and year of activity (e.g. *EL1234_2000.xxx*). Files referring to a specific point should be further identified by hole name or sample number (e.g. *EL1234_2000_ddh2.xxx*, *EL1234_2000_samp01.xxx* where *xxx* is the file extension). See also section on media labelling and presentation. The data should be included as an Appendix (or Appendices) to the report. A description of the data set(s), as well as the media on which it is supplied, should be included in the list of contents of the report.

Eg: Appendix II - Porosity and Permeability Results: NTGS Yeuralba DDH 1
Files: Summary on *EL1234_2000_DDH1.txt*
Data on *EL1234_2000_DDH1.dat* (ASCII format)
(Two 1.4 mb floppy disks)

4.2 File size

The amount of data that may be incorporated into a single data file depends on the practicalities of each individual case. With deep wells and considerable log and test information, it may be appropriate to report one hole per file. On the other hand, large numbers of shallow wells with only a few tests may more appropriately be reported as a number of holes to a file. In general, files should not exceed 1 Mb in size and the number of files should be minimised to allow easy handling. Seek the Department's advice if in doubt.

4.3 File compression

Files may be submitted in compressed form. Lossless compression (e.g. LZW) is preferred, and of course is mandatory for all text-containing files. Where the JPEG compression algorithm is used, the compression or loss ratio must be such that the resultant file suffers no significant visual degradation. If software other than WinZip or PKZIP is used for compression, then the relevant decompression software should be included. Where proprietary rights prevent inclusion of compression software, do not compress files.

If compressed files are submitted, the file names listed in the list of contents should refer to the expanded file names, not the compressed file names. Files may be archived.

4.4 Acceptable media

Acceptable media for the submission of digital data, ranked according to preference, are:

- Compact disks (CD-ROM)
- 1.4 Mb floppy disks (3.5in) DOS formatted
- Exabyte 8 mm data tapes

- Digital linear tapes (DLT)

Choice of media will normally depend on the volume of data to be submitted.

4.5 Media labels and presentation

All media (tapes and discs) should be clearly labelled with:

a. Sufficient detail to link the item to the tenure report (e.g. tenement number and date), and
b. A list of files contained therein.

The tapes and discs should be contained in an appropriate envelope or envelopes, and bound into the report if hardcopy is submitted. Each envelope should be clearly marked with the appropriate identifier heading (e.g. tenement number and date), appendix number and the media listing including file names, formats and descriptions.

Additionally, each media item must contain an ASCII readme.txt listing including file names, formats and descriptions.

The data should also be included as an appendix (or appendices) to the report. A description of the data set(s), as well as the media, on which it is supplied, should be included in the list of contents of the report.

Eg: Appendix II - Diamond Drill Hole results - Tawallah prospect.
DDH McA2 – Summary on *tawallah .tx*t
Data on *EL1234_2000_drill.dat* (ASCII format)
(Two 1.4 Mb floppy disks)

5. Comment

Exploration reporting guidelines are undergoing convergent evolution across Australian jurisdictions. This may result in the eventual development of uniform national exploration guidelines and perhaps a nationally integrated exploration search interface. The current draft of the national reporting guidelines is available for comment at <http://www.dme.nt.gov.au/save/ggdpac97.html>.

> Eventually, this guide will form the basis of an Australian Mineral Exploration Reporting document type definition (DTD) in accordance with the Standard Generalized Markup Language (SGML) standard, ISO 8879:1986. … When reports are consistent with a DTD model and geoscience databases more uniform, state departments will be able to supply more focused, consistent, intelligible and manipulable data to their clients, and multi-state research will be facilitated. It is stressed, however, that the development, acceptance and eventual use of this guideline, is not dependent on the use of SGML, and that DTD development is a separate, subsequent, phase. (*Introduction*.)

In an effort to promote national exploration conformity, this document relies both on guidelines developed interstate, particularly in New South Wales and Queensland, and on ideas derived from BHP Discovery. Permission to incorporate this material is both appreciated and acknowledged.

6. More information

Enquiries regarding the submission of annual reports and digital data:

<table>
<tr><td>Mineral Exploration Reporting</td><td>Titles Geologist
Ph: +61 8 8999 7816
Fax: +61 8 89817861</td><td>Petroleum Exploration Reporting</td><td>Petroleum Geologist
Ph: +61 8 8999 5342
Fax: +61 8 8981 7861</td></tr>
<tr><td colspan="2" align="right">Titles.Geologist@dme.nt.gov.au</td><td colspan="2" align="right">Petroleum.Geologist@dme.nt.gov.au</td></tr>
<tr><td>Report formats

Digital Submission of Reports</td><td>Reference Geologist
Ph: +61 8 8999 5281
Fax: +61 8 8981 7861</td><td>Uniform National Reporting Guidelines</td><td>Manager, Information Services
Ph: +61 8 8999 5279
Fax: +61 8 8981 7861</td></tr>
<tr><td colspan="2" align="right">Reference.Geologist@dme.nt.gov.au</td><td colspan="2" align="right">Manager.ISB@dme.nt.gov.au</td></tr>
</table>

7. Summary Table

Report Element	Data Type	Format and Presentation	File Suffix
Text or summary	Word processor (MS Word97 preferred) or ASCII text	Hard copy plus digital file, meaningful name (Tenure and date). Lossless compression only (e.g. LZW) [.doc, .wp, .rtf, .pdf, .txt]	.pdf
Plans, figures, graphic logs, geolocated grids, geolocated contour maps	Raster	Lossless compression strongly preferred . Lossy compression (e.g. JPEG) must ensure selected ratio provides adequate output. [.tif, .jpg, .ers]	
	Vector and contour overlay files	ER Mapper files Microstation, [.erv, .dgn, .dxf]	
Photographs	JPEG or TIFF image	As for raster images. [.tif, .jpg]	
GIS compilations	Digital maps	MapInfo and Arc View files	
Point data sets	Spreadsheet (MS Excel97 preferred) or delimited ASCII file with readme file	Header or README.txt file. Delimiters: pipe, comma, space, tab, semi-colon or colon delimited with column headings and units.	.txt .xls .dat
Airborne geophysics	Located, levelled data	Standard ASCII code. Formatted in GDF or GDF2	.gdf
Seismic sections	CGM/CGM+ format graphic files plus SEG-Y format files	Meaningful file names: *line_name_#*.cgm *survey_name_date*.sgy	.cgm .sgy
Downhole geophysics	LAS (preferably Version 2.0) or ASCII files	Hard copy plus Log ASCII or delimited ASCII files. Meaningful file manes: *log_#*.las, *well_name*.las Delimiters: pipe, comma, space, tab, semi-colon or colon delimited with column headings and units.	.las .dat

Information management initiatives: Mineral Resources Tasmania

Peter Rice[1] & Andrew Betlehem[2]
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[2]Geographic Business Systems, Salamanca Square, Battery Point, Hobart 7004

Abstract

Project TIGER is upgrading information management systems and processes within MRT. The information resource created by the project will form part of a larger whole-of-government Land Information System Tasmania (LIST). The project is managed according to Government of Tasmania project management guidelines to ensure the project outcomes are achieved.
The system architecture is based on a three tier client, application server, data server model where data storage and processing is managed on central servers with Windows, browser and Unix clients. System development employs a Rapid Application Development (RAD) methodology where application initiation and refinement is driven from the logical data model using the GeoCASE tool.

Introduction

Mineral Resources Tasmania (MRT) has traditionally managed an information archipelago with a number of discrete processes for each island that are matched to a particular need. This model for information management cannot meet the demand of clients, both internal and external, for a more accessible integrated and flexible information resource. Project TIGER (Tasmanian Information on Geoscience and Exploration Resources) aims to push MRT into a sustainable position to achieve business outcomes based around delivery of integrated information services.

TIGER Strategy

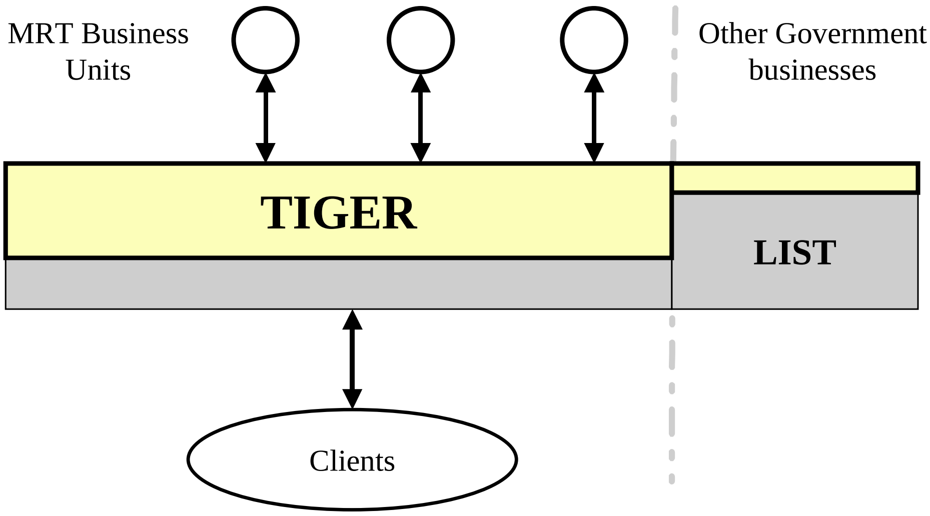
Project Plan

The objectives of Project TIGER are to be delivered in the form of:

- An integrated information resource for MRT;
- Operational processes that focus on business objectives;
- An information management system that is a component of a broader Tasmanian Government Land Information System.

Integration of TIGER and Land Information System Tasmania (LIST), which is developed and operated by the Department of Primary Industry, Water and Environment (DIPWE), will form part of an extended Whole of Government Land Information System that will permit easy and rapid interchange of data between government agencies (Figure 1).

Figure 1: Business model for TIGER and interaction with Land Information System Tasmania (LIST).



Project TIGER is being executed as a number of phases. Phase 1 involved the development of a prototype of an integrated system for display and query of tenement information. Phase 2 focussed on the input of data into existing databases to increase the overall holding of data in digital form. Phase 3, which is in progress, is the planning and development and implementation of an integrated data management system for MRT and the transformation of information management processes to support the delivery of integrated information to clients. Phase 3 is scheduled to be completed by the end of 1999.

Future phases of the project which are yet to be funded will develop delivery of data to clients via the World Wide Web and extend the data management system implemented in Phase 3 to incorporate new digital data.

Project Management

The project is managed in accordance with Project Management Guidelines formulated by the Department of Premier and Cabinet which contain recommendations for quality management of project governance, documentation and execution. The Director of Mineral Resources Tasmania is the Project Sponsor and chairs the Project Steering Committee which comprises five State Service Executives. A full time Project Manager has day to day control of the project and is assisted by a Project Team of 2 full time staff. Project quality review is carried out by the Department of Premier and Cabinet.

Expert advice on system architecture and system integration is provided by Dr Peter Zwart, and an organisational consultant advises on change management and organisational issues that arise from the implementation of TIGER. System development and programming is carried out under contract by Geographic Business Systems Pty Ltd.

Data Management

The following strategies underpin the system design and organisational changes encompassed by Project TIGER:

- There is only data; the different data types such as text, spatial, document or video sum to form MRT corporate data;
- There is a single logical data model for TIGER;
- The TIGER data model forms part of a larger Whole of Government Land Information data model;
- The physical implementation of the TIGER data model will be in a single RDBMS environment;
- For each mode of access there will be a central access point which controls security;
- Changes should be initiated and driven from the logical model by using a CASE tool;
- All spatial data will be referenced to a single horizontal datum and expressed in a single coordinate system;
- Wherever practical use will be made of national standards for data definition and representation.

TIGER Architecture

Existing Systems

At the commencement of Project TIGER Phase 3 a number of unconnected application focused systems were in place. The systems were developed at various times to meet specific data management needs of groups or projects within the organisation.

Analysis revealed that the project would not realise its objectives using the existing systems as they are disparate in a technical, operational and management sense. However the existing systems had to be considered as they influence:

- Existing applications to be supported;
- Data migration; and
- Use of existing hardware.

TIGER System Requirements

For MRT to realise the goal of delivering a fully integrated information service the fundamental information management philosophy has to change from being application centred to data centred. From a system point of view TIGER had to implement an open systems three tiered – client, application server and data server model for data processing with centrally managed servers for data storage and applications delivered on Windows and Web based clients.

Interfaces to the TIGER system consist of four classes:

- maintenance and editing of textual and spatial data;
- ad-hoc read only queries from internal users;
- fixed read only queries from internal and external users;
- data transfers between TIGER and other Tasmanian Government systems.

Other more general requirements are:

- That the system will separate data management and application environments logically and physically;
- The system will be scalable in terms of the number of concurrent users, applications, volume of data and external interfaces it can support;
- The system programming practice should maximise the re-usability of database objects and code.

High Level Architecture

The system architecture employed by Project TIGER is an extension of the LIST data management architecture (Figure 2). The LIST and TIGER data servers are Oracle RDBMS's which can replicate data either on demand or periodically to suit the needs of both organisations. TIGER applications can either be hosted on desktop clients or accessed via an application server. Desktop client applications are either Windows applications such as ArcView or browser based applications built specifically for the project. Alternatively an application server delivers Unix applications such as ArcInfo via Xterminal or Windows clients.

Future phases of the project may deliver data via the World Wide Web by replicating data to the LIST delivery server where it is optimised for WWW users.

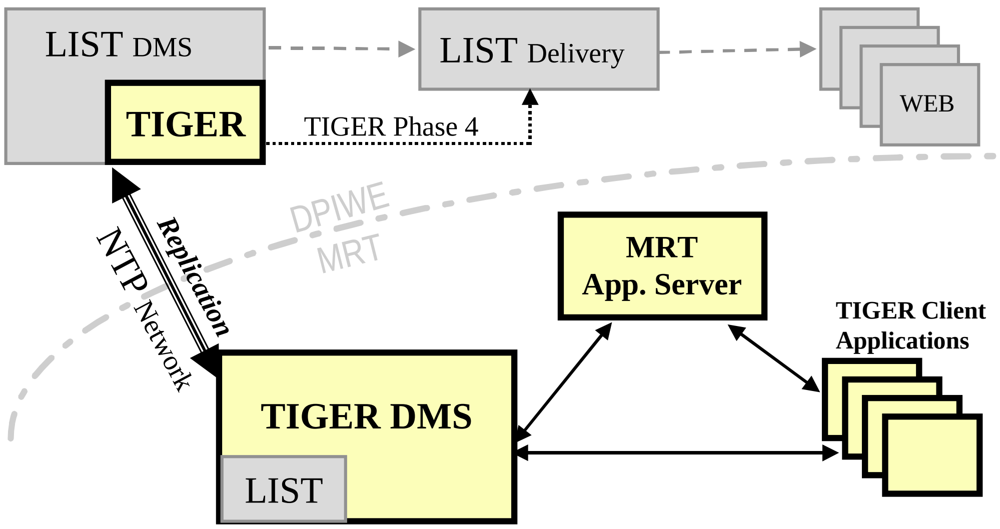


Figure 2: TIGER-LIST system architecture.

Intranet Browser Deployment

TIGER intranet applications are being deployed using an internet derived three tier architecture; a browser client, an application (web) server and a data server. The browser client differs from conventional client-server applications in that applications reside on a central application server, not on each client.

Conventional client-server architecture distributes complexity to all parts of the organisation and is enormously labour intensive leading to high maintenance costs. Project TIGER addresses traditional client-server architecture problems by building HTML based applications that run on a web browser. For TIGER distributing new applications is simply a matter of sending an email containing a URL to users; there is no need to install applications on each PC or set up ODBC drivers. The volume of data transmitted across the network is minimised as data is used only for display on the client.

Browser deployment presents the user with applications in a familiar environment that simplifies implementation and reduces training requirements.

Project TIGER intranet applications employ Oracle 8 Enterprise Server, Oracle Application Server 3 and Microsoft Internet Explorer 4 as core platforms.

Development Methodology

Functional Requirements

Development is initiated by seeking input from owners of data management processes and key data users. Analysis of the interaction between current work processes and data can be summarised succinctly in process flow diagrams. After current work processes have been documented improvements can be designed and incorporated into the new system. The process flow diagrams are an effective way to communicate system requirements to system developers.

Data Modelling

Conventional use of Computer Aided Software Engineering (CASE) tools records information in a data dictionary on the analysis and design phases of a project and a tremendous amount of work is done to ensure the accuracy of this information. Traditionally, application development is a separate process from data modelling and it is a manual process to incorporate the data dictionary information into the application. This traditional approach to system development is inherently inefficient and allows inaccuracies to propagate through each development stage.

The entire data model, and the data required for development the of software for TIGER is stored within the CASE tool, this substantially reduces the chance of propagating errors.

Rapid Application Development

The development methodology for Project TIGER is Rapid Application Development (RAD) through the use of CASE tools and prototyping.

GeoCASE is the CASE tool used throughout Project TIGER. GeoCASE's data dictionary (the data it holds about the system) is extensible, giving the flexibility to extend the data dictionary to store system development information as well as the data model in the same, central repository. For example, traditional data model information (entities, attributes and relationships) can be stored alongside system development information such as 'Does this entity have a delete button on its form?' and 'What is the plural of this entity?'.

Prototypes of TIGER are rapidly produced with GeoCASE and users are actively involved in the development process, producing early feedback on the system. System analysis can only uncover so much; prototypes will give users a very real sense of what the final system will look and act like, making it much easier for them to criticise and improve on the system. This feedback enables the development of TIGER to closely resemble user requirements and usage patterns.

In most RAD methodologies, the prototype is a piece of ‘throw-away’ code, possibly produced on a platform different to the final product. The prototypes produced for TIGER Phase 3 are developed in exactly the same way as the final production system, reducing the overall development time.

Project TIGER achieves rapid development through the use of GeoCASE. Two major features of GeoCASE are:

1. All system development information is stored along with the data model and

2. GeoCASE’s template language enables the production of source code directly from the CASE tool.

GeoCASE includes a BASIC language (TEMPLO) which is used to extract data dictionary information to produce the programs and other files. Templates are written in TEMPLO to produce each file of the system. For example, a template is written to produce the SQL create table statements, another produces the data entry forms. A number of these templates combine to produce the entire system from the data model and the system can be generated within a matter of minutes.

All programs are written with a consistent approach by using templates in this manner. This is particularly important for Project TIGER because a consistent user interface is required for a wide variety of database applications. Since the layout and performance of the system is incorporated within the templates, TIGER will have a very similar “look and feel” user interface for all of its various components, reducing the amount of user training required and increasing the confidence of users.

Discussion

Project TIGER is an ambitious attempt to upgrade information management technology and practices within MRT. To have the best possible chance of success a methodology has been adopted whereby a project business plan and system strategy has been documented that includes detailed descriptions of project execution and governance. Integration of TIGER with a whole of government land information system has been made possible by the adoption of technical and management standards across a number of organisations within the Tasmanian Government and Local Government. The use of standardised system architecture and widespread use of internet technology is delivering well packaged geoscientific information to a wide audience.

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Directions and developments of spatial information within the Geological Survey at PIRSA

Greg Jenkins[1] , Alan Mauger[1] & Steve Bell[2]
[1]PIRSA Mineral Resources
[2]PIRSA Information Management Services
GPO Box 1671, ADELAIDE SA 5001

Databases containing the Geological Survey's spatial information reside in Oracle, ARC/INFO and ERMapper systems, with some project data held in temporary working areas in desktop systems. The master databases run under Unix operating systems.

Point data are maintained in Oracle, with a complex but efficient attribute table structure linked to a central site table which contains each site's spatial data. Sophisticated and user-friendly interfaces are available for querying and extraction of data by staff. The addition of a spatial database engine (SDE) was investigated some time ago but was rejected due to its high cost at the time. It has been possible to carry out normal business operations without the use of SDE. Due to the reduction of cost of SDE, it is now being considered again. Line and polygon/region data are maintained in ARC/INFO, with various mechanisms for extraction and use of the data.

Methods of public access to PIRSA's digital spatial data are according to user needs. Complex and specialised queries can be carried out in house by PIRSA staff according to the client's specifications. More common queries can be carried out by clients in possession of integrated digital datasets available on CD-ROM. Internet access to current tenement data has been publicly available for some time. It is planned to progressively provide access to other subsets of the geoscientific databases through Internet map server technology.

The GDA94 datum is to be applied to all of PIRSA's spatial databases by 31 December 1999.

Year 2000 compliance checking is being carried out by PIRSA's information technology staff, and will be completed within three months.

Directions and Developments of Spatial Information within the Geological Survey at PIRSA

Greg Jenkins

Alan Mauger

Steve Bell

PIRSA Mineral Resources

PIRSA Information Management Services

PRIMARY INDUSTRIES AND RESOURCES SA

Government of South Australia

- Present state of spatial data systems
- Future directions

PRIMARY INDUSTRIES AND RESOURCES SA

Government of South Australia

Topics of Discussion

- Oracle
- ARC/INFO
- Raster images
- Project data
- Data access methods
- GDA94

PRIMARY INDUSTRIES AND RESOURCES SA

Government of South Australia

Oracle

- SA_GEODATA
  - Drillholes
  - Samples and analysis results
  - Field observations
  - Mineral deposits
  - Sample library
  - Geological monuments

Oracle

- Base table (SITE) contains spatial information
- Complex interrelationship of tables gives efficient storage and rapid retrieval
- Data maintenance through graphical interface
- Scope for addition of map windows
- Spatial Database Engine option

ARC/INFO

- SA_GEOLOGY: line and polygon/region data
- Spatial information management is integral part of system
- Maintenance through system interfaces
- Cartographic production
- GIS modelling

Raster Images

- Manipulated through ERMapper
- Landsat TM total coverage acquisition for SA
- Geocoding at accuracy dependent on project requirements
- HyMap data for SWIR-responsive minerals
- Digital orthophotography

Project Data

- Minimal and short term use only
- Incorporation into Corporate databases wherever possible
  - Total conversion
  - Regular upload

PRIMARY INDUSTRIES AND RESOURCES SA

Government of South Australia

Data Access

- According to user needs
- Standard graphical interfaces
- Specialised queries carried out in-house
- CD-ROM datasets
- Internet access
  - Tenements
  - Map server technology

PRIMARY INDUSTRIES AND RESOURCES SA

Government of South Australia

GDA94 - SA Government

- Whole of Government
  - Implementation from 1 January 2000
  - SA to adopt national transform parameters
    - For all but primary network geodetic adjustments
    - Spatially related datasets to remain synchronised
  - ESRI commitment
  - Cadastre already transformed
    - Available in other datums on request

PRIMARY INDUSTRIES AND RESOURCES SA

Government of South Australia

GDA94 - PIRSA

- November 1999 ARC/INFO spatial library transformation for release 1 Jan 2000
- November 1999 SA_GEODATA transformation for release 1 Jan 2000
- Hardcopy products in GDA94 from 1 Jan 2000
- Last AGD66 1:250,000 map about to be printed, later maps to be produced in GDA94
- GDA94 logo on all GDA94 products

PRIMARY INDUSTRIES AND RESOURCES SA

SOUTH AUSTRALIA

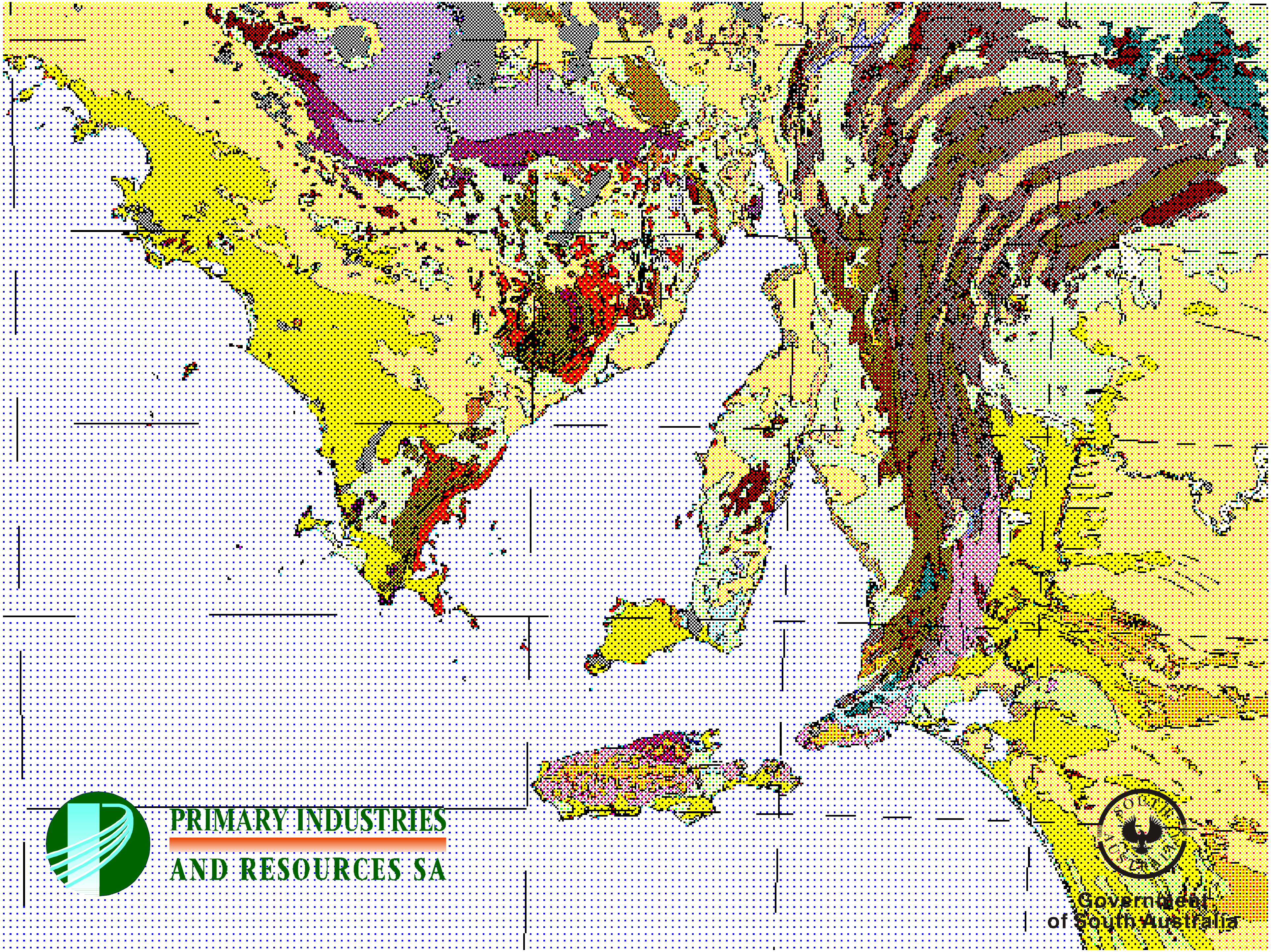
Government of South Australia

GDA94 - PIRSA - Tenements

- Policy yet to be finalised. Objectives:
  - No ground to be lost or gained
  - Native Title implications are to be minimised
  - Boundaries on old datum to effectively disappear as quickly as possible.
  - Likely to move to graticular block allocation system

PRIMARY INDUSTRIES AND RESOURCES SA

Government of South Australia


PRIMARY INDUSTRIES
AND RESOURCES SA
Government
of South Australia

Information management—maximising the benefits of GIS in AGSO

Ian O'Donnell
Australian Geological Survey Organisation
GPO Box 378 Canberra, ACT, 2601

Introduction

Following decisions made after the Federal election in October 1998 the Australian Geological Survey Organisation (AGSO) is now part of a reshaped Department of Industry, Science and Resources (DISR). The old Department of Primary Industries and Energy has been abolished by distributing its functions to existing and new portfolios. The Land and Water component of AGSO is now part of a new Department, Agriculture, Forestry and Fisheries of Australia. Two Branches from the old Bureau of Resource Sciences, namely the Petroleum Resources Branch and the Mineral Resources & Energy Branch have been transferred to AGSO.

AGSO's role as the national geological research and survey organisation has not altered; its objectives and planned outcomes are still focused on:

- mineral and petroleum promotion;
- marine zone resource management;
- geohazards and geomagnetism;

AGSO's outputs comprise a wide range of geoscientific-based goods including maps, databases, datasets and atlases, written and oral reports. It also comprises delivery of services including geoscientific advice, monitoring, data access and training which are purchased to meet the needs of AGSO clients.

In addition to AGSO clients, there are a wide number of stakeholders who take a special interest in AGSO. Extensive collaboration and cooperation are required with these stakeholders if the geoscience research needs of Australia are to be successfully met. AGSO is actively involved in high level cooperation with industry, the State/NT geological surveys, CSIRO, universities, Cooperative Research Centres, and the international geoscience community.

Such a diverse range of functions, coupled with advanced computing technology leads to an extraordinary amount and type of information being generated. AGSO has a responsibility to Government, industry and the public to manage this information and make it visible and accessible, regardless of the way they may have been collected, processed or stored.

In preparing this paper we have compared our current data management strategies with those we reported on at the 1997 GIS Forum. At that time most geological surveys, including AGSO, were intent on implementing enterprise-wide information infrastructures to manage and deliver geoscientific information. Over the last two years there has been a push for greater transparency and accessibility to organisational information. To this end data infrastructures have been established, for example

Queensland's QSIIS and Western Australia's WALIS at the state level. On a broader scale development of the Commonwealth's ASDI is proceeding and world-wide the global spatial data infrastructure (GSDI) is beginning to take shape. These initiatives and the intrinsic requirement to make information available to clients has influenced the direction AGSO is taking with respect to its information management (IM) strategy.

This paper discusses the IM strategies employed by AGSO to meet the needs of the organisation and our clients. A number of GIS and data manipulation projects are briefly discussed to illustrate the broad nature of our scientific undertakings and how our IM strategies are helping to maximise the application of GIS.

Information management in AGSO

Managing information is a complex task, one made especially difficult for AGSO due the breadth of our mapping and research activities. We have a significant investment in legacy data that exists in hard copy and also digital form, such as 9 track tapes, for which we have a management and preservation responsibility. AGSO's scientific programs acquire terabytes of data per annum which is variously processed, integrated, modelled and published by anyone of a 100 technical software applications used in the organisation. To overcome some of the problems that obviously arise from the collection, data manipulation and delivery processes an AGSO wide Information Management Strategy has been developed.

Information Management Strategy. AGSO's Information Management Strategy for the period 1998/99 deals specifically with spatial information and outlines the organisation's commitment as national custodian to managing this important resource. It defines AGSO's vision for IM – that is "to create a user-friendly geoscience information system that supports the full extent of AGSO's business needs, encapsulating a single uniform environment for all data types based on relational database management system architecture". All staff who handle geospatial data in any way have a role to play in the IM strategy, but implementing the actions in the document can be grouped into corporate and divisional responsibilities. Some of the milestones as defined in the strategy that have recently been achieved are discussed below.

Corporate Database Policy. The completion of an audit of every Division's database holdings identified the databases and data assets that exist across AGSO. This has helped shape the framework for a Corporate Database Policy, an action identified in the IM Strategy, which is designed to align the corporate data management processes with the business objectives of the organisation. It defines rules for corporate database management that firstly ensure compliance with Government requirements and secondly that the organisation's information is preserved in such a way that it is accessible to current and future projects and the broader community.

One of the fundamental principles of the policy is the preservation and accessibility of primary data. It is important that this data be separated from derived, modified or interpreted data, that is the user can always get back to the primary data.

Many of AGSO's corporate databases are *national* databases because they contain

data that is significant in the national context. As such, the long term management of these databases or classes of data falls to an assigned custodian and the appropriate Divisional Information Officer who are jointly responsible for maintaining the quality and longevity of the data.
Considerable effort is also going into developing 'user friendly' interfaces for these national databases, eg AGSOCAT and ORACOVS

With the recent transfer of the Petroleum Resources and the Mineral Resources and Energy Branches to AGSO the policy now needs to be updated. This is particularly important for the Petroleum Resources Branch who have significant IM responsibilities with the Chester Hill (previously Villawood) site, National Petroleum Databases and the Symonston Repository.

Divisional IM Plans. Under the IM Strategy each Division is now required to have an IM Plan that defines their commitment to the organisation's principles for information management and delivery. As such the Plan includes the Division's business critical data and information outputs and how this is managed in terms of storage and accessibility, data consistency and quality together with strategies for dealing with legacy data.
The Plans are to be completed by April 1999 and these in conjunction with the IM Strategy will help define AGSO's IM Model.

Data Administrators. With over sixty, often quite diverse geoscience projects, mechanisms are needed to ensure compliance to the principles of data management that we have embraced. Experience leads us to believe that devolving responsibility for information management to project personnel does not always guarantee conformity to standards and the generation of quality products. We have overcome these problems by allocating responsibility for IM matters in each Division. For example, under the IM Strategy, Divisions are required to appoint a Divisional Data Administrator (DDA's), and Projects to assign a Project Data Officer (PDO's). Amongst other tasks DDA's are responsible for maintaining quality, including undertaking data validation. As the title suggests PDO's handle the range of IM matters at a lower level such as ensuring milestones are developed and met, data is archived, sources of data are recorded and so forth. For the most part, the role of a PDO is not a full-time one and in the case of small projects one person may manage numerous projects. The important thing here is that responsibilities are assigned.

Engaging the projects
Significant gains have been made on developing an IM model and an accountability framework for the management of information across AGSO. Notwithstanding this, AGSO has to learn that managing information as a corporate asset should be an integral part of the science of the project, not an administrative requirement that has to be signed off when the project ends.
To drive this organisational and cultural change a new corporate information management project will be introduced this coming FY. The outputs of this project will be an AGSO Information Business Model which articulates the vision and expectations and operational features for an AGSO Corporate Information Management System, together with an implementation strategy and operational plan for the development of information management for each project output category.

This new project will be lead by Dr Lesley Wyborn.

The AGSO Geoscience Data Dictionary. AGSO has always applied nationally and corporately recognised specifications and standards to its geospatial work. In an effort to more closely define a standard for GIS products the AGSO Geoscience Data Dictionary has been developed. It is a specification for structuring geoscientific GIS data and specifies rules such as allowable layer names, feature types, attribute widths and values. Initially developed for geological data types, we plan to expand it to cover other areas, such as petroleum and hazards mapping. Validation software has also been produced which automatically checks whether GIS data complies with the data dictionary, highlighting any errors that may need correction prior to the release of data.

AGSO plans to store spatial data in Oracle tables rather than discrete GIS layers such as ARC/INFO coverages. To this end we are investigating the use of Oracle's spatial data cartridge, ESRI's spatial database engine, and similar packages. It is envisaged that in moving spatial data to Oracle further refinement of the Geoscience Data Dictionary will take place, and that much of the data validation that currently takes place post-production will take place during data entry.

Internet. The Internet is continuing to improve by providing efficient, economic and equitable access to information. AGSO's website continues to expand to meet the demand for our vast store of geoscience data. New GIS tools enhancing presentation of AGSO's digital datasets have been introduced and the number of databases available for online interrogation has doubled over the last year with a commensurate increase in their use by AGSO clients. Current developments in online commerce, encryption and database connectivity will see the organisation making further advances in the use of Internet technologies over the coming year.

The National Geoscience Information System (@ngis) continues to provide a gateway to Australian geoscience resources on the Internet. Over the last year significant improvements have been made to the @ngis Data Locator (a web based data mapping tool), allowing users to plot datasets with AGSO's national geophysical data coverages as backgrounds. The @ngis mapping technology continues to draw interest from other spatial data agencies and has been deployed by AUSLIG as an interface to their 'Spotlite' satellite image datasets.

Establishment of a Corporate disk store. AGSO intends to store as much data as possible in its Oracle Database Management System (DBMS). How data that cannot be stored in this environment, such as legacy data, processed project data outputs and products will be stored is still being considered. What we do know is that such a storage facility would need to provide on-line and near on-line access to data.

Currently AGSO products falling outside the Oracle DBMS are being stored in proprietary data structures in a dedicated area known as the 'Corporate disk'. This UNIX facility houses all scientific data, AGSO products, commonly used datasets, such as GEODATA TOPO-250K, coastlines, standard symbology and so forth. A public domain software product called *samba* is being introduced to allow storage and access from the PC systems. Currently 50 gigabytes of data are stored and the volume of data is growing at an ever-accelerating rate as more projects realise the benefits of having a long term custodian for their outputs.

Implementation of Validation Procedures. Pre-release validation is now carried out on all GIS datasets. Increasingly this is being performed by an independent party. The validation focuses on fundamental aspects of data quality and completeness, thus ensuring that:

- licensing and copyright issues are agreed upon and the price of the product has been determined to provide consistency with similar data types across AGSO;
- data format, precision and compression, are valid for the target software system, and the names of files, layers, and covers are consistent;
- the data is complete, attributed, and that associated files, tables, and metadata are included as correctly appropriate;
- the data complies with the AGSO Geoscience Data Dictionary
- data is housed in the corporate database

In an effort to minimise the amount of corrective work required after validation progressive audits of projects are being introduced. There may not be advanced warning of these audits and they can be conducted at any point in the production process. The audits focus on:

- the strategic direction taken by the project in regard to anticipated GIS outputs;
- the quality of the GIS;
- the manner in which the GIS data is structured;
- the compliance of the GIS to organisational standards, and
- the capacity for the datasets to ultimately contribute to the corporate information system.

Review of AGSO's product sales and distribution arrangements. A review of AGSO's product sales and distribution arrangements was conducted in July 1998 and of the eleven recommendations stemming from the review, a number are related to IM in AGSO. The most important recommendation is the decision to replace the Bookscan system and our current Products Catalogue with an Oracle based sales, client and product database. The new AGSO Catalogue is a general database of information on all AGSO's products, publications, datasets and resources. It will be used across the whole of the organisation via the Intranet, and by our external clients via the Web and should be online by the middle of the year. Entries for spatial products such as maps and GIS datasets are linked to full descriptions in a separate, Web-visible ANZLIC compliant metadatabase known as GEOMET.

Related to this, is the development of a more comprehensive and coordinated procedure for release of digital products, one, which demands that all AGSO products be recorded in GEOMET prior to their release. GEOMET has the potential to become the national geoscientific node of the Australian Spatial Data Directory (ASDD) under the Australian Spatial Data Infrastructure (ASDI) currently under development.

The Review also recognised the role the Internet will play in disseminating information to our clients. While we have a prototype of an Internet based product ordering system operating at the moment we plan to implement online credit card verification systems, transaction monitoring and online delivery systems in the near future. Additionally, rather than use AUS.GEO News as the primary vehicle for initial release notifications for our products we intend to use the Web under our ‘What’s new’ icon. Data and product releases will then not be tied to a two-month publication schedule.

Geocentric Datum of Australia (GDA). AGSO commenced the transition to GDA in February 1998 by migrating its National Geoscience Databases to GDA. Project data and field surveys will be progressively moved to GDA such that AGSO will be GDA compliant by mid 1999. Any new datasets released after this date will be based on GDA. The GDA logo appears on all datasets and maps so that they are immediately identified as GDA compliant and accompany notes provide further explanation to the user.

Legacy data. AGSO has a significant stock of legacy material and data, the value of which should not be underestimated. In a pragmatic sense dealing with this comes down to two issues, what to retain and how. Divisions are required to develop strategies for dealing with their legacy holdings, a real challenge for the Petroleum and Marine Division with its large stock of physical and digital archives.

Application of GIS technology in AGSO

The application of GIS and related technologies in AGSO spans the full spectrum of our science. Some of the more diverse and interesting GIS and data manipulation projects that represent the integration of data for analysis, interpretation and decision planning are reported on below.

Expert Systems

The Cooperative Research Centre for Landscape Evolution and Mineral Exploration (CRC LEME) project is building its own expert systems (ES) module to assist with the synthesis and modelling of geoscientific datasets and concepts. Whereas GIS such as Arc/Info provide data storage and commands for routine data operations such as overlying datasets and griding, ES are able to link knowledge with GIS data layers to create ‘intelligent’ systems for predictive modelling.

The principle objective of the ES project is to develop a computer system capable of predicting regolith, landscape and geochemical exploration characteristics for a relatively unexplored region based on available data. In effect a system that can predict within defined confidence limits, what the regolith is, how it got there and some indication of its exploration potential
It will be used to develop and test models of landscape evolution in different environmental settings within Australia.

The ES system will be able to:

- To speed up traditional reconnaissance regolith mapping approaches;
- Store and apply current knowledge of regolith, landscape, geomorphic processes, geochemistry and their own relationships;
- Retrieve from archive, integrate and model regolith datasets both at regional, district and prospect scale.

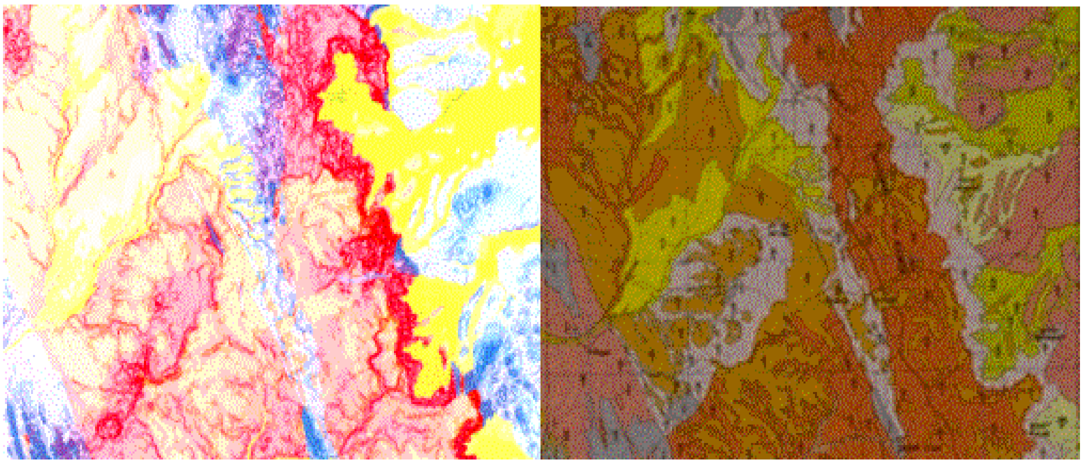


Figure 1. A - Regolith mapped using an expert system approach B – Regolith landforms based mainly on photo interpretation.

AGSO's Cities Project

This work is aimed at developing a better understanding of the elements at risk in urban communities and in their vulnerability to the impact of geohazards. From this understanding emergency managers and planners will have the necessary information and decision support tools to aid in the mitigation of geological hazards. This will lead to safer, more sustainable and, consequently, more prosperous communities.

The past two years has seen the development phase of the project in which techniques, methodologies and standards have been developed and tested in several 'real world' pilot studies. During this time large amounts of disparate data, including the built, human, political, natural, legal, spatial and scientific environments, from many sources within the community have been collected, collated and analysed.

Integrating this data (both spatial and non-spatial) into a GIS to enable us to start modelling scenario events of the key elements at risk (buildings, people, lifelines, etc) in communities, is proving to be a major achievement. Though far from complete, we are well down the road towards technology and data availability enabling us to model and visualise real time *Risk-GIS*.

Remote Sensing Activities

Radarsat. The NorthWest Shelf and Southern Margins projects acquired Radarsat imagery over their respective areas for the detection of oil seeps. In a special deal with Radarsat, imagery was received for every overpass and the best image then selected for processing. Oil seep areas were detected as changes in the sea surface roughness. This process has enabled a better definition of target areas for subsequent ship-based surveys, at this stage in the North-West Shelf area.

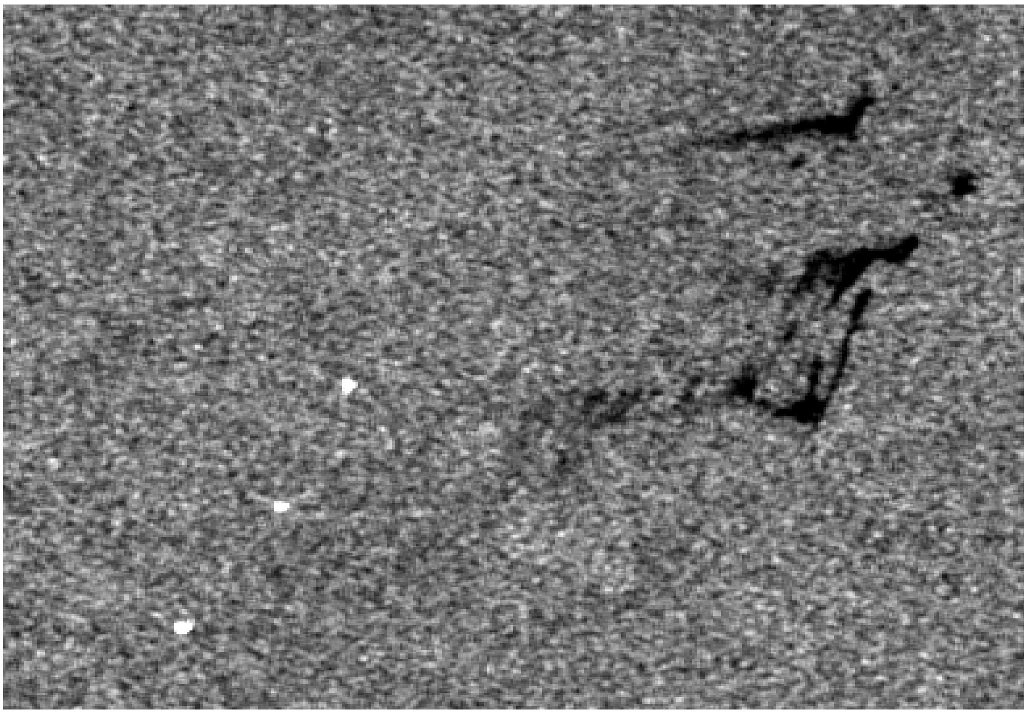


Figure 2. Detecting oil seeps – Radar image of a slick in NW shelf

Soft Photogrammetry. High resolution DEM and large scale orthoimage was created for part of the Cootamundra 1:250,000 sheet to assist with the interpretation of regolith and geological mapping. Aerial photographs at 1:50,000 scale were scanned and along with detailed ground control points were subsequently processed using soft photogrammetry techniques. The resulting DEM had a 10 metre ground resolution and the orthoimage resolution of 5 metres. Post processing of high resolution DEM and orthoimagery for the Yilgarn project generated more accurate base imagery for field mapping and thus improved the overall level of accuracy of the subsequent GIS.

Spectral processing of Landsat TM. Several Minerals projects continued to use the directed principal components and ratios method for the identification of clay, iron oxide and silica images to assist with regional regolith and geological mapping in semi-arid terrains. This method has proved useful both as a pre-field mapping interpretation, and post field mapping analysis. Examples of this imagery for 3 areas of the NABRE project will be bundled as products and released on CD during 1999.

Drought monitoring over PNG using AVHRR imagery. Remotely sensed data from the Advanced Very High Resolution Radiometer (AVHRR) satellite sensor was used to rapidly monitor and assess the 1997 drought experienced in Papua New Guinea. Data was acquired for a normal year (1996), the drought (1997) and the year of recovery (1998). The Normalised Difference Vegetation Index (NDVI) and surface temperature (Ts) calculations were used to create time difference images during this period.

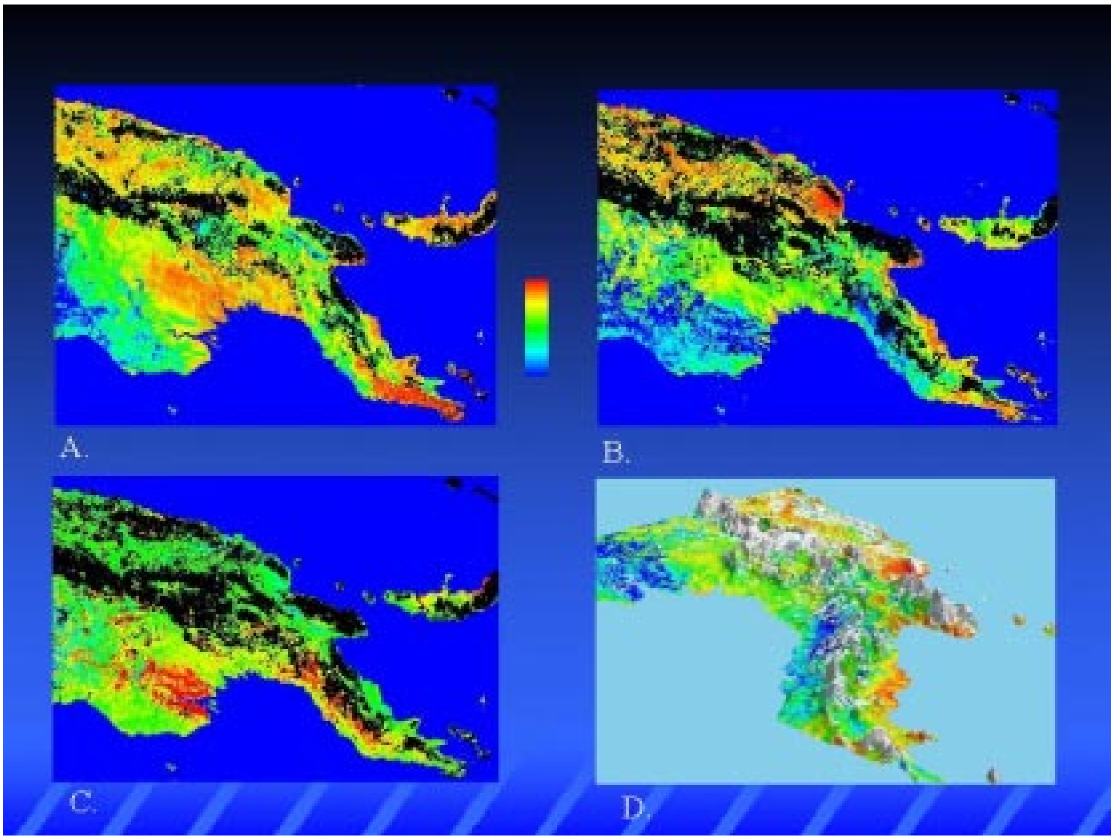


Figure 3. Drought monitoring in PNG with NOAA – AVHRR (VNIR, TIR) data. A - NDVI data for the September – October 1997 period (Note: blue on the colour scale represents decreasing vegetation, black is cloud); B – NDVI data for the November – December 1997 period, the height of the drought; C – Difference of images A and B where red indicates decreasing vegetation; D – Image B draped on USGS 30 sec DEM

<u>Volcanic Mapping-hazard and Information System (VMIS)</u>

The Town of Rabaul, in Papua New Guinea, was devastated in September 1994 by the simultaneous eruptions of Tavurvur and Vulcan. Most of the destruction was cased by ash fall and mud slides. Largely due to the eruption, a GIS, referred to as the Volcanic Mapping-hazard and Information System (VMIS), funded by AusAID, is being established to enhance the mapping capabilities of the Rabaul Vulcanological Observatory (RVO).

The objectives of the VMIS are to:

- Provide vulcanologists with the ability to produce maps quickly
- Perform hazard mapping and display potential impact
- Help in contingency and town planning
- Facilitate presentation for public awareness of volcanic hazards

Topographic base and volcanic hazard data has been collected for the five high-risk volcanoes – Rabaul, Manam, Ulawun, Lamington, and Karkar identified by the RVO.

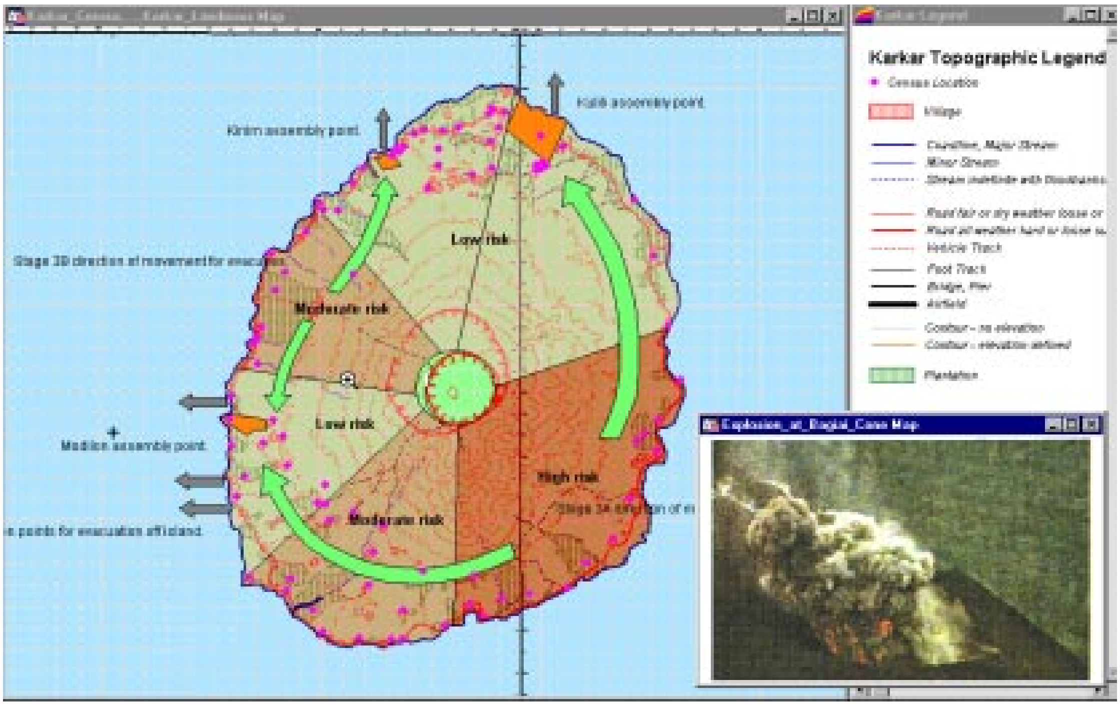


Figure 4. Selected datasets from the VMIS for the Island of Karkar, depicting eruption risk rated zones, evacuation routes and evacuation mobilisation points.

In addition there is also a national dataset detailing all volcanoes, digital movies of volcanic hazards and previous eruptions, digital image catalogue for the extensive photo collection, 3d visualisation via vrml files, and multimedia tutorials demonstrating the use of the software and the VMIS.

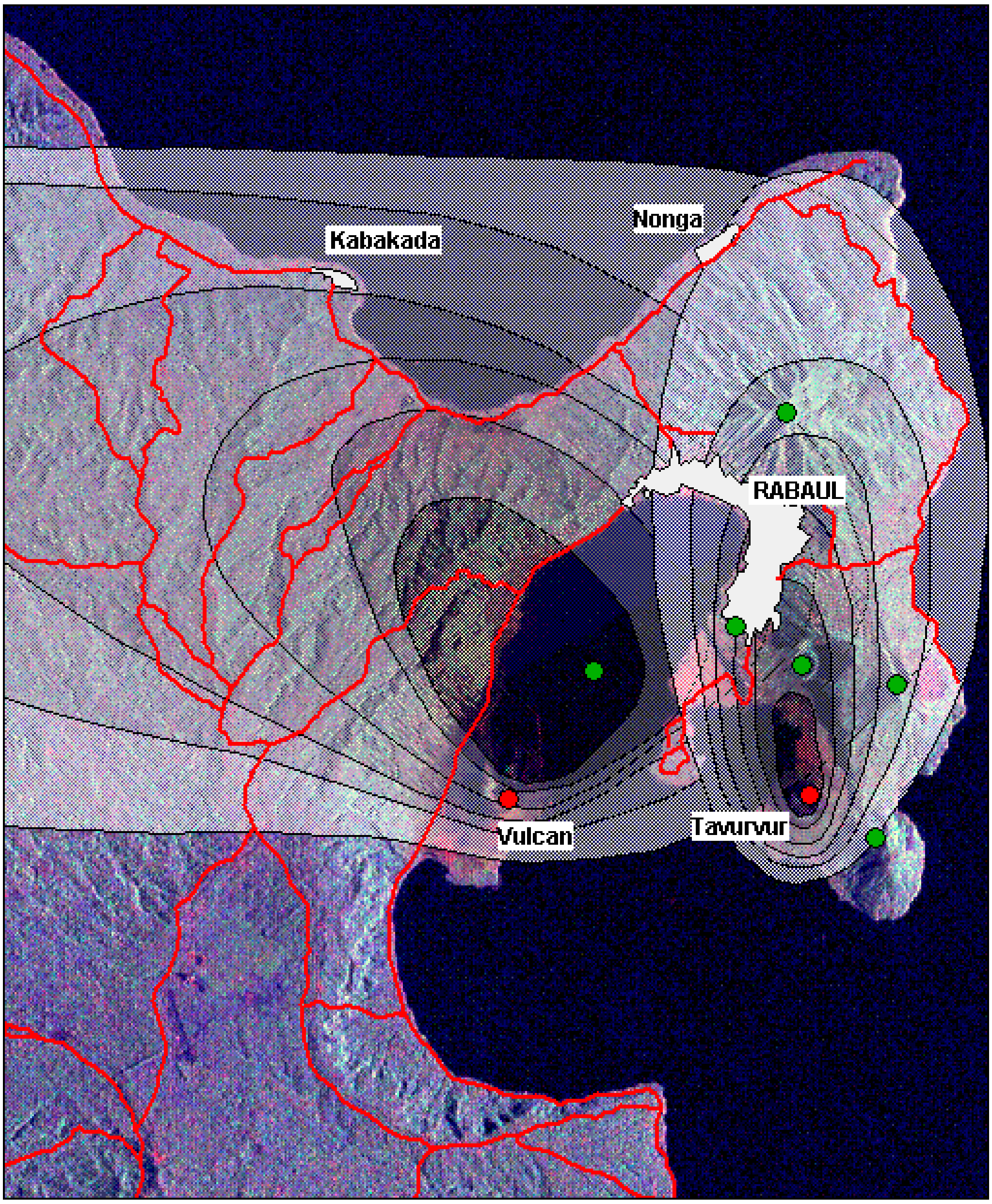


Figure 5. VMIS datasets for Rabaul region overlaying a Radar image taken approximately one month after the eruptions. The green dots represent monitoring stations, red lines road infrastructure and the shaded areas are degrees of ash fall-out from each of the events.

It is certain that volcanos in the vicinity of Rabaul will erupt again. Hopefully the VMIS system may make it possible for the community to live more safely in this volcanic environment.

Future trends

The value of geospatial data is now widely recognised and applied which accounts for the increasing demand to access the massive amounts of data at all levels of government. Satisfying this growing demand through fast retrieval systems is the challenge for all of us. Our ‘data marts’ will have to be established and maintained in such a way that they keep pace with this demand - this will require coordination, commitment and resources well beyond what is currently being allocated to this task.

There will be singularly more reliance on the World Wide Web for disseminating all types of information to the desktop. The Internet with its spatial query and visualisation tools will provide the user with the freedom to transparently access data and geoprocessing facilities on distributed sites. Geoscientific interpretation and analysis will increasingly be done this way on a ‘pay as you use’ basis. While this transition is occurring the time should be used constructively to plan, develop and implement the underlying standards, quality aspects and principles that will be critical to these dynamic systems.

With the downward trend in commodity prices, lower profits and explorers moving offshore there has never been a better time to assist the industry by improving accessibility to the geoscience data holdings resident in agencies around the country. This would prove to be all that more valuable as the industry moves out of the recession and looks to re-establishing their geoscience databases. Of course the demand for geoscientific information goes well beyond exploration, there are multiple disciplines that require this type of data for sustainable development and community safety applications. The diversity of GIS project activities in AGSO is a good example of this.

The geoscience community has to respond more quickly than it has to date in providing access to geoscience ‘data discovery’ facilities based on spatial data infrastructure models that exist for other fundamental datasets such as cadastre, road centrelines, and postcodes. This national geoscience data system, for want of a better name, would act as a virtual information warehouse that can be accessed through various gateways at state and national level. Geological surveys, both Federal and State, Tertiary bodies and the private sector should actively contribute to the creation of this system. Attaining such a goal should not be the difficult, unlike the United States, there are only seven States/NT and the Commonwealth to coordinate and the work already being done on other spatial data infrastructures around the country is paving the way forward.

Such a model will be dependent on agreed standards for the construction, exchange and management of data. Recent work being done by the Government Geoscience Information Policy Advisory Group (GGIPAC) on guidelines for submission of Statutory Exploration data, on behalf of the Chief Government Geologists Conference (CGGC), is introducing a new level of standardisation across the industry. Furthermore, AGSO is prepared to continue to play its role in establishing standards for geoscience data construction, depiction and exchange.

Conclusion

Dividends from the effort that has gone into IM over recent years in AGSO can now be seen in a number of ways. There is a better appreciation of data and information management *per se,* although the cultural turnaround necessary, whereby projects think first and foremostly about how and where they will store their data still has some way to go. The Database Policy will ensure that national and corporate databases take on new importance as the nation’s primary geoscience data repositories. AGSO’s products, especially GIS datasets are now of consistently higher quality and the corporate data store avoids duplication and facilitates data integration for GIS work. Finally, the launch of the new ‘AGSO Catalog’ towards the middle of this year will be the key to future systems of Internet based data distribution and sales.

The challenge ahead of us is twofold. The development of a national geoscience data system has to be a priority if we are to keep pace with the emerging demand for geoscience information. Secondly, developing the capacity to capture the knowledge that is related to the data and information will require some effort and will impact on the way we have traditionally gone about our business. Knowledge management is the next rung in the accrual and distribution of assets ladder and will most certainly be a topic on the program at the 5th National Forum in 2001.

Acknowledgments
Many thanks to Geoff Lawford, Rod Ryburn, Dmitar Butrovski, Lesley Wyborn, John Creasey, Russell Hay and Greg Scott who have contributed in various ways to this paper.

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Characterising hydrocarbon seepage in Australia's Timor Sea (Yampi Shelf) using integrated remote sensing technologies

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The Yampi Shelf comprises part of a Palaeozoic to Mesozoic flexural ramp margin, which dips to the north-west away from the flanking cratonic (Proterozoic) Kimberley Block. The basement itself has a rugose topography, with some basement blocks being elevated by as much as 500 m above the surrounding basement. Progressive onlap of the Early Cretaceous post-rift seals onto the ramp means that the regional seal both thins and becomes sandier margin-ward. In margin-ward locations, some prominent basement highs are 'bald' of seal, whereas in others, the seal thins dramatically onto the back of topographically prominent, landward-dipping tilt blocks.

Acquisition of three geochemical remote sensing technologies, namely RadarSat Synthetic Aperture Radar (SAR), water column geochemical sniffer (WaSi) and Airborne Laser Fluoresensor (ALF) data, and their integration with regional seismic and high resolution bathymetry data over part of the inboard Yampi Shelf, has revealed the following. Hydrocarbon seepage was confirmed independently by SAR, WaSi and ALF, though the relative response and sensitivity of each technology to seepage of varying rates and compositions appears to be quite different. Overall, the principal seeping hydrocarbon is dry (<1% wet) thermogenic gas ($\delta^{13}C$ = -42.45). The first-order control on both the distribution (and perhaps the composition) of the detected seepage is the thickness of the regional Early Cretaceous seal. Small, localised (<4-5 km across) seeps tend to be related to seismically prominent gas chimneys associated with topographically conspicuous tilt blocks. These chimneys, whilst spectacular, result only in relatively small amounts of seepage, typically 2-4 times background; this seepage appears to be related to a thinning of the regional seal across the tops of the tilt blocks. All of the major seepage, which in some areas reached >300 ppm in the bottom waters (~100 times background), is closely associated with prominent basements horsts which are bald of seal. These intense zones of seepage tend to be large (10-30 km across), though their seismic expression is muted, and is often restricted to diffuse zones of relatively poor coherency, or the presence of a very prominent amplitude anomaly at the seafloor.

SAR anomalies are located ~10 km inboard from the intense WaSi anomalies, right over a prominent basement 'headland' which defines the regional 'zero-edge-of-seal'. The SAR anomalies appear to be due to the leakage of relatively heavy, biodegraded oil, of a type similar to that found in the Cornea oil discovery nearby. This offset between the location of seeping dry gas and heavy oil (if truly causal and not due to drift associated with currents and wind etc), may be reflecting the differences in the relative permeability of gas and oil. The oil, being heavier, may have migrated further inboard, and only leaked when the seal is virtually gone; in contrast, the more mobile gas ‘breaks through’ the seal sooner, and as a consequence, dry gas seeps are developed in more basin-ward locations.

These observations suggest that where the regional seals thins over inboard basement highs, or where the seal itself pinches-out regionally, are prime areas in which to capture a ‘snap-shot’ of the present-day migration across a margin. It may well be that such areas are actually outside (that is inboard of) the exploration explorers' permits. Consequently, the best place to gain an understanding of the hydrocarbon charge characteristics of a permit may well not be within the permit itself.

AGSO petroleum data model perspective: essential elements for geoscience data models

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In the recent past, AGSO's database development has evolved on a discipline basis as each project recognise in hindsight the shortcomings of such development as opposed to corporate models, however group recognised the power and rigour that relational databases bring to research activities. It is easy to it has at least allowed different groups to focus independently on key aspects that they can bring to a collective corporate model in terms of standards and innovative approaches.

Numerous benefits flow from utilising multi-disciplinary approaches to problem solving in the geosciences. With a properly integrated data model such multi-disciplinary approaches are possible, the time spent capturing data will be minimised, and more time will be available for producing solutions. Data captured for one discipline is more accessible to other disciplines.

Within the Petroleum Industry competing standards groups exist such as PPDM and POSC, that have public models that vendors and organisations alike can contribute to and utilise. However these groups models concentrate on downstream petroleum industry requirements and do not encompass the range of datasets that AGSO has as its core business. Difficulties lie with the disciplines where no standards have existed, such as biostratigraphy, palaeogeography and geochemistry. With these we have had to go it alone, albeit trying to consult with any other organisations that have similar development needs.

The earth models developed in the Petroleum Division of AGSO allow the opportunity to incorporate key geoscience concepts into a corporate data model. AGSO's Petroleum databases have been built from the basic data up, with considerable effort to capture data in a way that allows smart processing of the data, and integration of a variety of disparate information. Central to these considerations is time series searching (TSS), which is the ability to access/retrieve geoscience data based on its biostratigraphic or radiometric age in millions of years.

Analytical well data (eg geochemistry, porosity, permeability) relate only to the well which it represents, via a well name and a measured depth from the surface. Relating analytical data in adjoining wells can not be done on depth, but only on its relative age in millions of years. AGSO has devised a programmatic method to replace manual techniques such that any depth can be converted into an age or vice-a-versa. However TSS can only be applied successfully if a strict set of standards is imposed. It is these standards and data model concepts that we have been discussing with both POSC and PPDM.

Conceptual break throughs such as TSS turn data into information and ultimately knowledge, in that they become predictive tools. Additionally TSS functionality can turn database systems from bins to store non-relatable 2 or 3 -dimensional data into systems that can produce a myriad of 4-dimensional solutions.

Introduction

The Australian Geological Survey Organisation (AGSO) is Australia's national geological survey (www.agso.gov.au) and is a research agency of the "new" Department of Industry, Science and Resources. AGSO was established in 1946 as the Bureau of Mineral Resources, Geology and Geophysics (BMR) and has grown and matured to be one of the world's most technically advanced geological surveys, and it is the only one with responsibility for a whole continent.

AGSO's present responsibilities are to provide geoscientific maps, research and information to support sustainable development of Australia's mineral and petroleum industries, management of the Australian Ocean Territory, identification and mitigation of geological hazards, and sustainable management of Australia's land and groundwater resources.

Petroleum database initiatives

In terms of petroleum, AGSO jointly administers with the Bureau of Resource Sciences (BRS) any data acquired under the Petroleum (Submerged Lands) Act 1967, which comprises data from beyond the three mile nautical limit. Several Oracle based databases and front-ends have been developed since the early 1980's to help stimulate exploration within Australia, comprising both onshore and offshore data. These include:

PEDIN (historical data from petroleum well completion reports and geophysical surveys) - http://www.agso.gov.au/information/structure/isd/database/pedin.html

STRATDAT (biostratigraphic data from wells) www.agso.gov.au/information/structure/isd/database/stratdat.html

ORGCHEM (Organic chemistry data {eg Rock-Eval} from wells) - www.agso.gov.au/information/structure/isd/database/orgchem.html and

RESFACS (Reservoir, facies and hydrocarbon shows data from wells) - www.agso.gov.au/information/structure/isd/database/resfacs.html

When designing our data models, a key objective has been to produce a design that captures the detailed data in a technically competent manner, and allows better use of data in information systems. Design of the models and applications has been influenced by the major differences between the scales at which AGSO works on geoscientific problems, and the needs of our industry clients. Typically AGSO has the role of promoting areas for licensing rounds, usually focussing on regional play concepts and basin wide petroleum systems, whereas our industry clients are interested in working at the play and prospect level for individual licence blocks. With its strong research background in a number of geoscience disciplines (biostratigraphy, palaeogeography, geochemistry), AGSO has strived to produce not only comprehensive detailed datasets that provide access to basic and interpretative data, but to produce geologically intelligent application systems that programmatically utilise the data to produce products required by ourselves and our clients at whatever scale is required.

Discipline related datamodels

In the recent past, these discipline databases emerged across AGSO as individuals in different divisions in the organisation became database aware and saw the need for capturing their data. Increasingly however the organisation is being challenged by how to manage its growing number of databases, which encompass a diverse range of geosciences. AGSO currently has 70 production relational databases across such diverse fields as biostratigraphy, nuclear explosions, earthquakes, ground water, mineralisation and tsunamis (www.agso.gov.au/information/structure/isd/database/). These require management both in terms of front-end development as well as producing consistently structured models that meet the growing number of database standards. On AGSO's website, most of our standard authority tables are available (http://www.agso.gov.au/information/structure/isd/database/lookups.html), as well as database links to national standards naming conventions (National Stratigraphic Names Database – http://www.agso.gov.au/information/structure/isd/database/stratnames.html).

In petroleum we have been examining the various standards established by POSC and PPDM. Difficulties lie with the disciplines where no standards have existed, such as biostratigraphy, palaeogeography and geochemistry. With these we have had to go it alone, albeit trying to consult with any other organisations that have similar development needs. For this reason we have approached both PPDM and POSC with models for biostratigraphy and timescales to help the development of standards.

Corporate focus: integrated datasets

We now face even bigger challenges, which involve the integration of our petroleum databases to a corporate model. This is not a simple task, and there are no immediate solutions. It requires long term planning, with the ultimate aim of having integrated datasets, be they based upon either minerals, petroleum, groundwater or hazards data sets.

Numerous benefits flow from utilising multi-disciplinary approaches to problem solving in the geosciences. With a properly integrated data model, the time spent capturing data will be minimised, and more time will be available for producing solutions. Data captured for one discipline is more accessible to other disciplines. We will be able to reduce the costs of front-end development and maintenance as we move away from discipline based databases to adopting more normalised data models. More importantly it will allow AGSO the opportunity to incorporate some key geoscience concepts into the corporate data model. One such concept that we have developed at AGSO, is referred to as time series searching (TSS).

Biostratigraphy and time series searching (TSS)

Correlation between wells

In North America, the oil industry emerged during the 1900's whilst lithostratigraphic nomenclature was all that was available to relate between wells, meaning that formations would be used to correlate between wells. Modern biostratigraphy and sequence stratigraphy concepts have shown how diachronous such lithostratigraphic correlations can be, resulting in erroneous maps and cross-sections based on these concepts. In Australia however, the oil industry emerged during the late 1960's when micropalaeontological breakthroughs occurred, allowing accurate biostratigraphic age dating to occur. Thus most of the well data in Australian oil provinces contain reliable biostratigraphic data which was the starting point for our STRATDAT database.

STRATDAT facilitates the use of TSS, which is the ability to access/retrieve geoscience data based on its biostratigraphic or radiometric age in millions of years. Analytical well data (eg geochemistry, porosity, permeability) in different tables relate only to the well which it represents, via a well name and a measured depth from KB. Each analytical method will have measurements from each well with attributes describing the record in more detail. Relating analytical data in adjoining wells can not be done on depth, but only on its relative age in millions of years. AGSO has devised a programmatic method to replace manual techniques. It has only become possible because of 50 to 100 work years of palaeontological effort by AGSO's Timescale group to understand the relationships between different biostratigraphic zones and fossil classes. Performing this task for an entire continent for every class of fossil was a massive but necessary undertaking. It is constantly under review and updatable because of the databases that we have established, and the product outputs that we have linked to the databases.

When comparing the geology in different wells, a geologist utilises biostratigraphic data in conjunction with physical rock attributes and log data to produce correlations. In this way, different packages of rock can be related in terms of rock units of equivalent age. However this is only generally done in log correlation applications, which are very limited in how they then deal with the correlations. Additionally all of the data in the databases must be loaded into the applications before the correlations can be utilised. AGSO's approach was to build the TSS functionality into the databases themselves via stored procedures and functions. TSS can only be applied successfully if a strict set of standards is imposed. It is these standards that we have been discussing with POSC and PPDM.

Sample bias

In any given well, the biostratigraphy comprises a set of samples from irregularly spaced spot depths or sample intervals. Usually sample depths are dependant on the location of either cores, which are placed to maximise information about reservoir intervals in sandstones, or sidewall cores which are placed in fine grained siltstone and shale units to optimise the biological diversity in the samples and thus getter a better biostratigraphic result. Regularly spaced sample intervals for biostratigraphy can be obtained from ditch cuttings. However this introduces the issue of reliability in the interpretation of the biostratigraphy due to contamination and caving that commonly occur with samples of this type.

Depth/Age curves

For any given well, with an essentially irregular set of samples, there will be a range of biostratigraphic picks for the highest and lowest occurrences of particular palaeontological zones. Apart from the biostratigraphy data in the well being irregularly sampled, there will also be depth intervals where no age data occurs and ages with no rock record (unconformities). The data may not have common "head to tail" upper and lower depth values. Zones that are actually physically present within the well may be missing from the data set because they have not been sampled by core or sidewall core, or because the biodiversity of the sample is poor and no palaeontological assessment can be made. Problems with assigning ages to analytical values from other discipline databases (eg organic chemistry), required us to derive a unique mathematical curve of depth versus age for each well. In deriving this curve, all the nuances of geological reality had to be accommodated in the algorithm, such as unconformities, sample inconsistencies, faults, etc. A function can then be applied to derive the age in millions of years at any depth in any well.

TSS products

Having derived depth/age curves we were able to develop a range of applications to facilitate geological analysis of analytical data by upper and lower age ranges. The list of applications and uses for this type of analysis continues to grow. Examples of the uses for mapping age based queries across a geological province include: thickness of a given stratigraphic unit; top and base structure maps; and contour maps of average values for any type of analysis (total organic carbon, porosity, thermal maturity, palaeobathymetry, etc). This system allows comparative age based maps of any analysis type to be made extremely quickly. Previously this would have never been attempted across a region or entire province, because of the onerous task that it entailed. Other uses that are beginning to emerge are the potential to re-display geological data in age (millions of years) rather than perhaps depth or two-way time. Examples include exporting the depth/age curves into log applications so the log curves can be redisplayed in millions of years rather than depth, or where seismic sections can be redisplayed in millions of years rather than two-way time.

Within our database tools (Oracle Graphics), options exist to display any analyte type as a graph of depth versus value (eg depth vs porosity). Using the link to the depth/age curves, they can also be displayed against age in millions of years, so that unconformities can be visualised within the sample sets. Similar tools with our palaeogeographic interpretations for each well, allow us to plot the palaeobathymetric data for each well and then derive a type of coastal onlap curve. With the link to the depth/age curves and our querying routines, we can quickly produce maps of palaeobathymetry for any given age range. This is a powerful tool for geological interpretation of the petroleum systems of the region where prediction of source rock or reservoir quality are required.

We have also developed links directly between cartographic applications (eg MicroStation) and our databases, such that the biostratigraphic zonations for Australia can be printed out as a chart on demand, or each time a change is made in the datum dictionary.

Future directions

There are numerous developments that AGSO is considering. We are currently exploring deployment of our databases on the web. Our first step is to establish them for internal AGSO use, and then if issues such as security and performance can be resolved, we will look at making them available for clients externally through our AGSO Home Page.

An AGSO wide corporate model is an ideal that we envisage will be of great benefit both financially and from a research viewpoint. We intend to direct attention to trying to achieve it as a long term goal.

Our discipline based petroleum databases depend on links to the location data in the PEDIN (NPD) database (wellname, latitude, longitude, etc) which is jointly managed with the BRS. PEDIN (NPD) is not POSC or PPDM compliant, and future attention will address the remapping of it to be more consistent with those standards. We believe that this task should be done in concert with the issues of an AGSO corporate model, as many of the other geosciences groups at AGSO (groundwater, minerals, etc) can benefit from the standardisation that the Petroleum Industry has undertaken. However each of those groups are currently undergoing establishment of national standards themselves, and trying to draw them all together may be an ideal that will be even more challenging than the many issues that the Petroleum Industry has being trying to deal with over the last ten years.

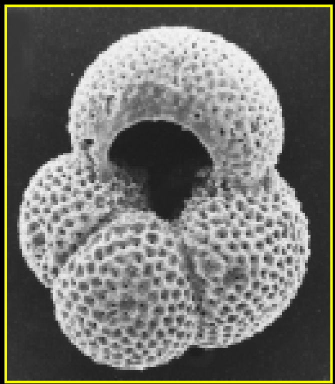
AGSO'S PETROLEUM DATA MODEL PERSPECTIVE

John Bradshaw [1] & Bruce Wyatt [2]

1 AGSO

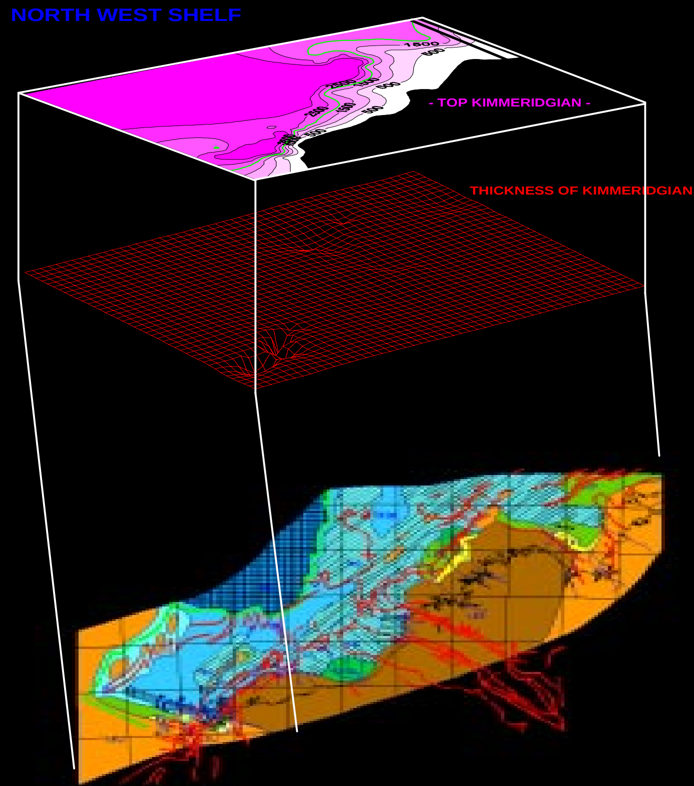
2 Wyatt & Associates

Essential elements for geoscience data models



+

Age (Ma) control



Talk Structure

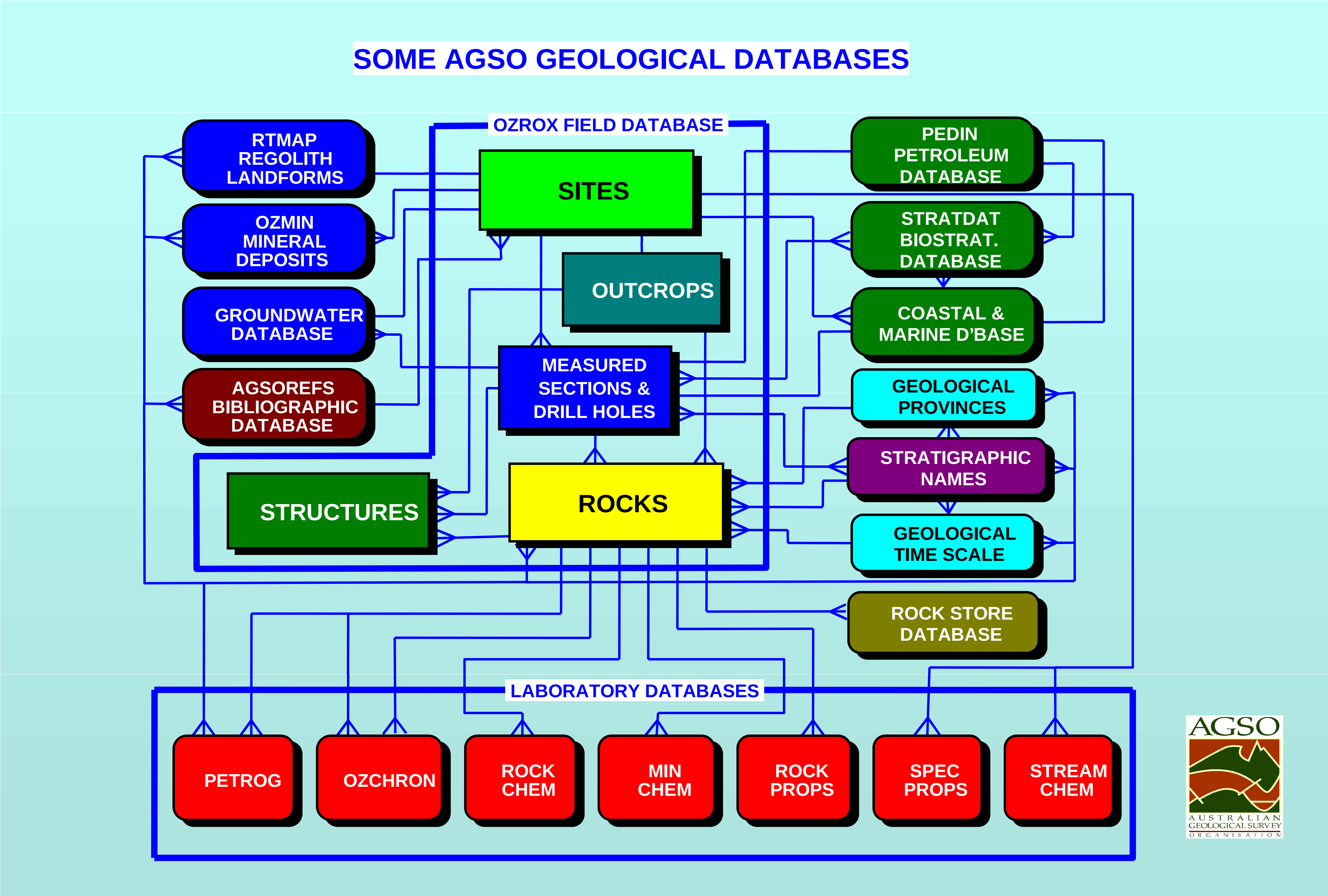
- Discipline databases vs integrated corporate models - *issues not solutions*
- Petroleum Initiatives - *influences on data model*
- Biostratigraphy & TSS
- TSS products
- Future objectives

Talk Structure

- Discipline databases vs integrated corporate models - *issues not solutions*
- Petroleum Initiatives - *influences on data model*
- Biostratigraphy & TSS
- TSS products
- Future objectives

Discipline databases vs integrated corporate models

- Over 70 Production Oracle databases across all divisions
  - Petroleum
  - Minerals
  - Ground Water
  - Hazards (Earthquakes etc)

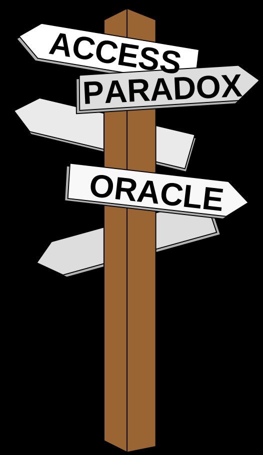

SOME AGSO GEOLOGICAL DATABASES
OZROX FIELD DATABASE
RTMAP REGOLITH LANDFORMS
OZMIN MINERAL DEPOSITS
GROUNDWATER DATABASE
AGSOREFS BIBLIOGRAPHIC DATABASE
SITES
OUTCROPS
MEASURED SECTIONS & DRILL HOLES
STRUCTURES
ROCKS
PEDIN PETROLEUM DATABASE
STRATDAT BIOSTRAT. DATABASE
COASTAL & MARINE D'BASE
GEOLOGICAL PROVINCES
STRATIGRAPHIC NAMES
GEOLOGICAL TIME SCALE
ROCK STORE DATABASE
LABORATORY DATABASES
PETROG
OZCHRON
ROCK CHEM
MIN CHEM
ROCK PROPS
SPEC PROPS
STREAM CHEM
AGSO
AUSTRALIAN GEOLOGICAL SURVEY ORGANISATION

Historical Perspective

- During 1990's project staff progressively became database aware
  - recognised need to capture data in relational models

  - used platforms / applications that they were comfortable with

X

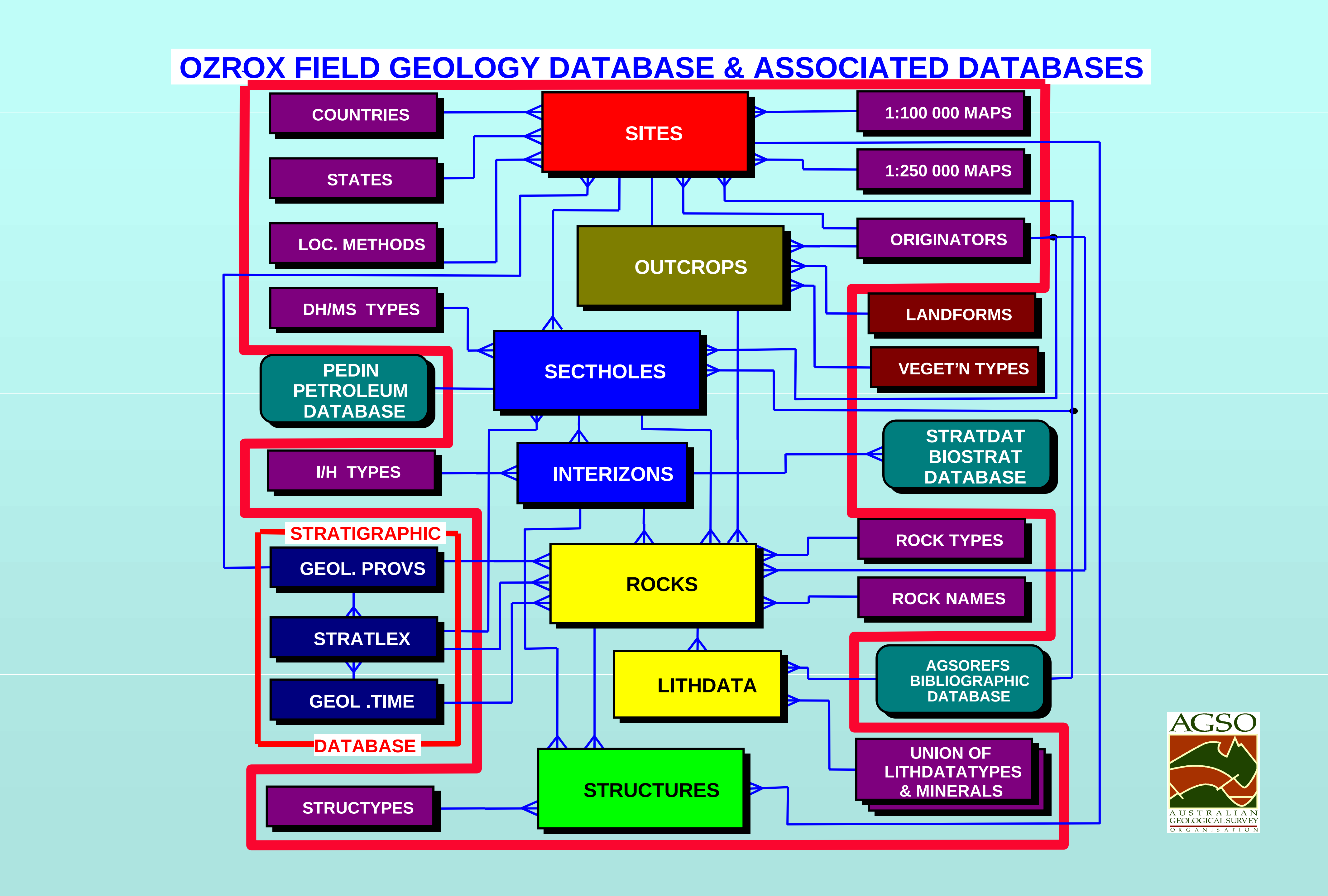


  - when projects satisfied with individual products then started to think about issues (standards {discipline}, consistent front-ends, corporate integration)

Outcome of “Database Evolution” via Discipline database approach

Integrated corporate model commonalities

- Many ;
  - Sites (Location)
  - Stratigraphic Units / Names
  - Lithology
  - Age / Timescales (millions of years - Ma)
  - Wells / Measured sections (outcrop)
  - Chemical analyses
  - Fluids
  - Spatial data, etc


OZROX FIELD GEOLOGY DATABASE & ASSOCIATED DATABASES
COUNTRIES
SITES
1:100 000 MAPS
STATES
1:250 000 MAPS
LOC. METHODS
OUTCROPS
ORIGINATORS
DH/MS TYPES
LANDFORMS
SECTHOLES
VEGET'N TYPES
PEDIN PETROLEUM DATABASE
INTERIZONS
STRATDAT BIOSTRAT DATABASE
I/H TYPES
STRATIGRAPHIC
GEOL. PROVS
STRATLEX
GEOL .TIME
DATABASE
ROCKS
ROCK TYPES
ROCK NAMES
LITHDATA
AGSOREFS BIBLIOGRAPHIC DATABASE
UNION OF LITHDATATYPES & MINERALS
STRUCTYPES
STRUCTURES
AGSO
AUSTRALIAN GEOLOGICAL SURVEY ORGANISATION

Corporate Data Model Issues

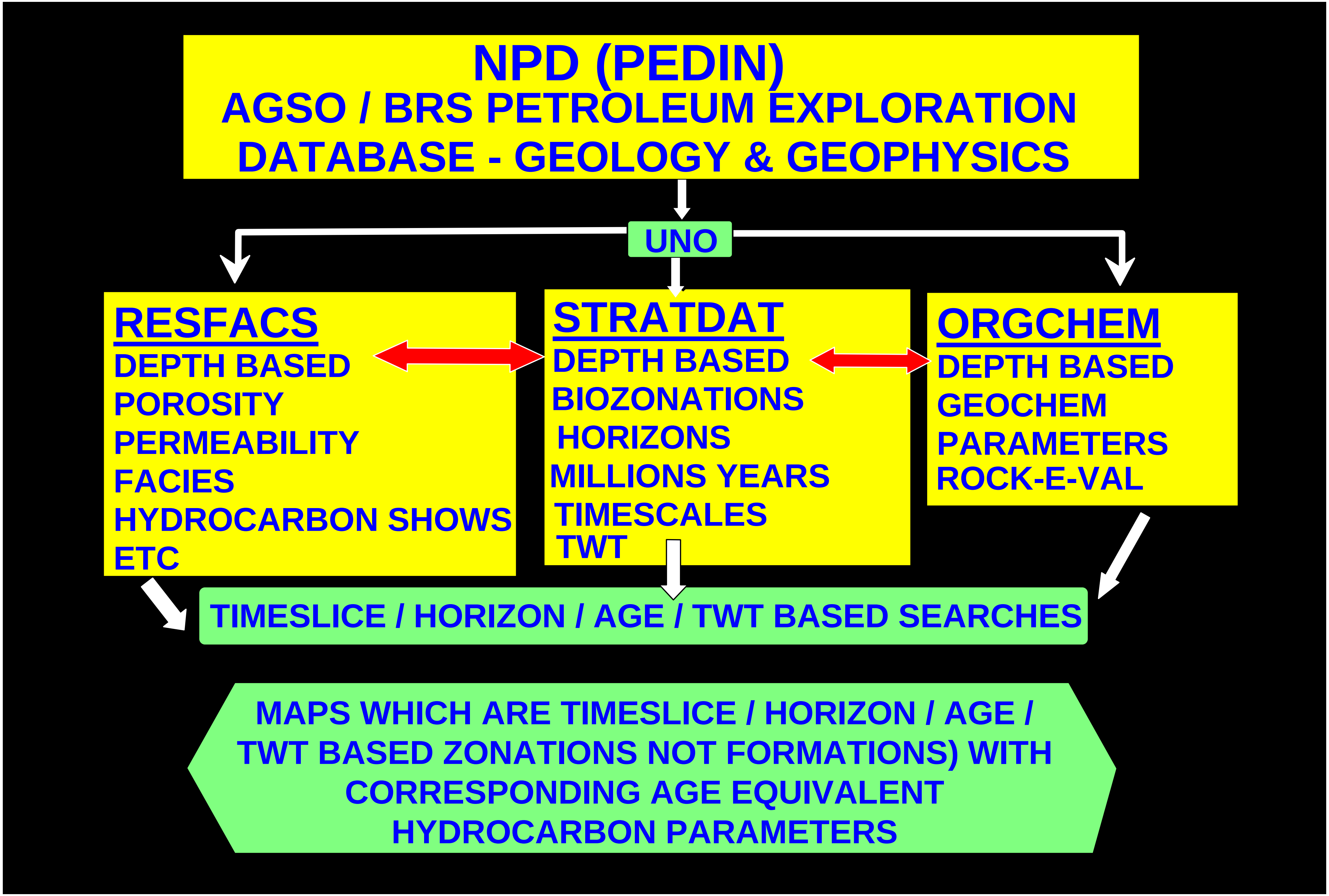
- Competing Standards - within and across disciplines
- No Standards
- Geoscience Theme / Concept to preserve

Corporate Data Model Issues

- POSC vs PPDM (petroleum) ; ANZLIC - CSDC - ASDI (spatial data) ; “Geoscience Data Model” (minerals)
- Geochemistry ; Biostratigraphy ; Timescales ; Groundwater ; Minerals ; Hazards
- Time Series Searching (TSS) ; integrated GIS capability

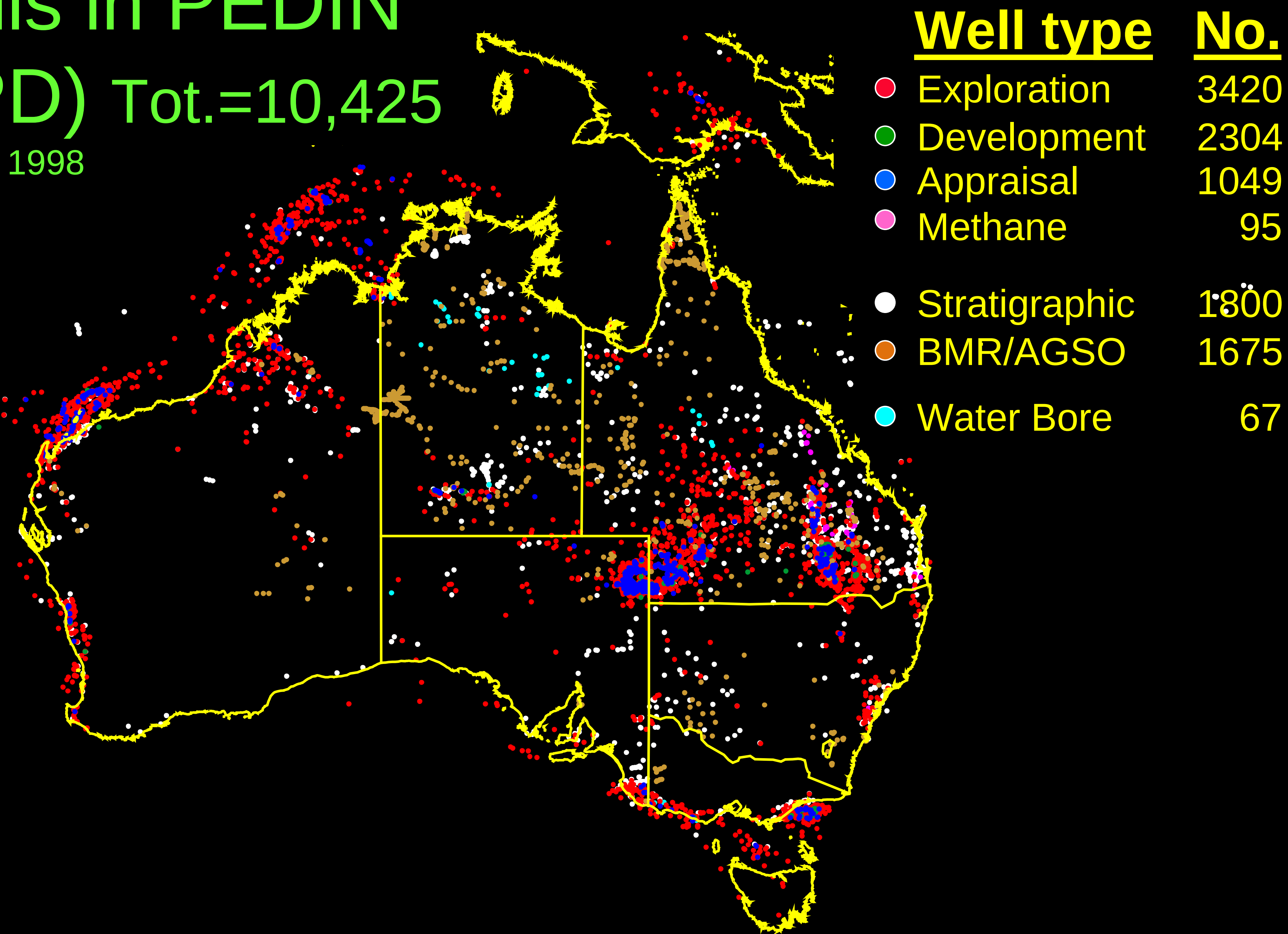
PETROLEUM DATABASE INITIATIVES

- 1982 developed ORGCHEM
  organic chemistry data - Rock-E-Val from wells
- 1984 developed PEDIN (NPD)
  historical data from petroleum well completion reports and geophysical surveys
- *1992 developed STRATDAT*
  biostratigraphic data from wells
- *1994 developed RESFACS*
  reservoir, depositional environments (facies) & hydrocarbon shows data from wells


NPD (PEDIN)
AGSO / BRS PETROLEUM EXPLORATION
DATABASE - GEOLOGY & GEOPHYSICS
UNO
RESFACS
DEPTH BASED
POROSITY
PERMEABILITY
FACIES
HYDROCARBON SHOWS
ETC
STRATDAT
DEPTH BASED
BIOZONATIONS
HORIZONS
MILLIONS YEARS
TIMESCALES
TWT
ORGCHEM
DEPTH BASED
GEOCHEM
PARAMETERS
ROCK-E-VAL
TIMESLICE / HORIZON / AGE / TWT BASED SEARCHES
MAPS WHICH ARE TIMESLICE / HORIZON / AGE /
TWT BASED ZONATIONS NOT FORMATIONS) WITH
CORRESPONDING AGE EQUIVALENT
HYDROCARBON PARAMETERS

Wells in PEDIN (NPD) Tot.=10,425

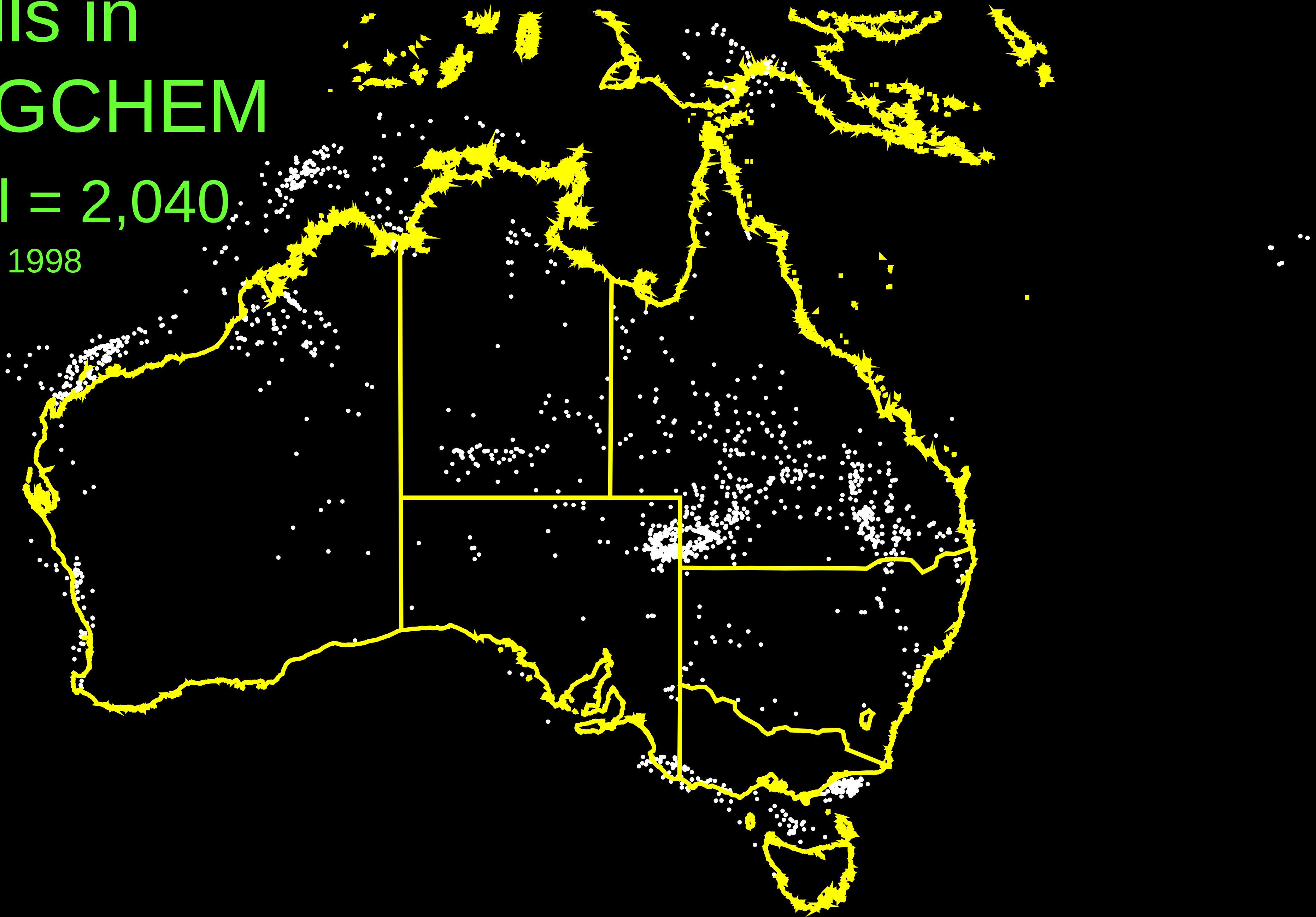
October 1998



Wells in ORGCHEM

Total = 2,040

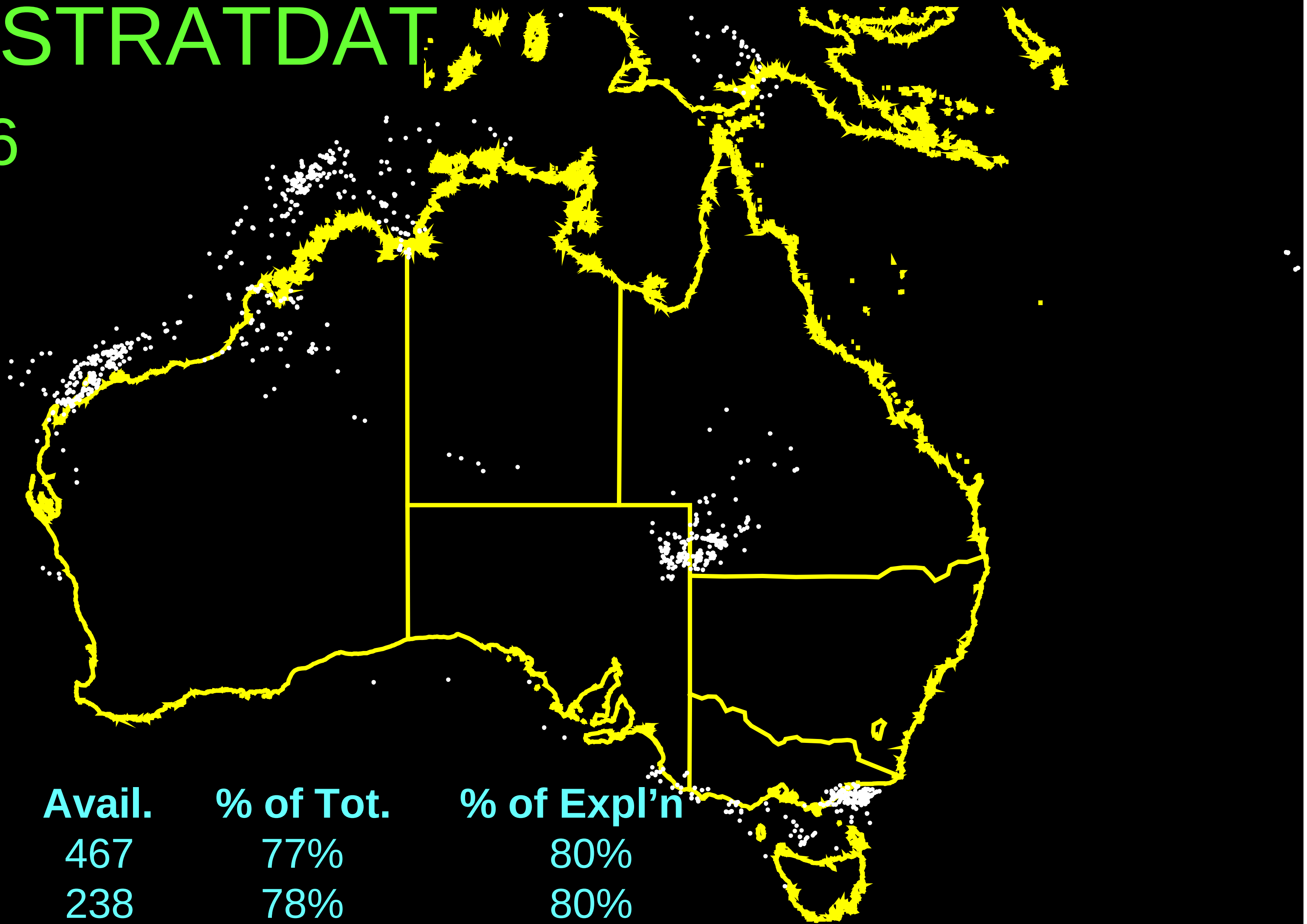
October 1998



Wells in STRATDAT

Total = 976

October 1998



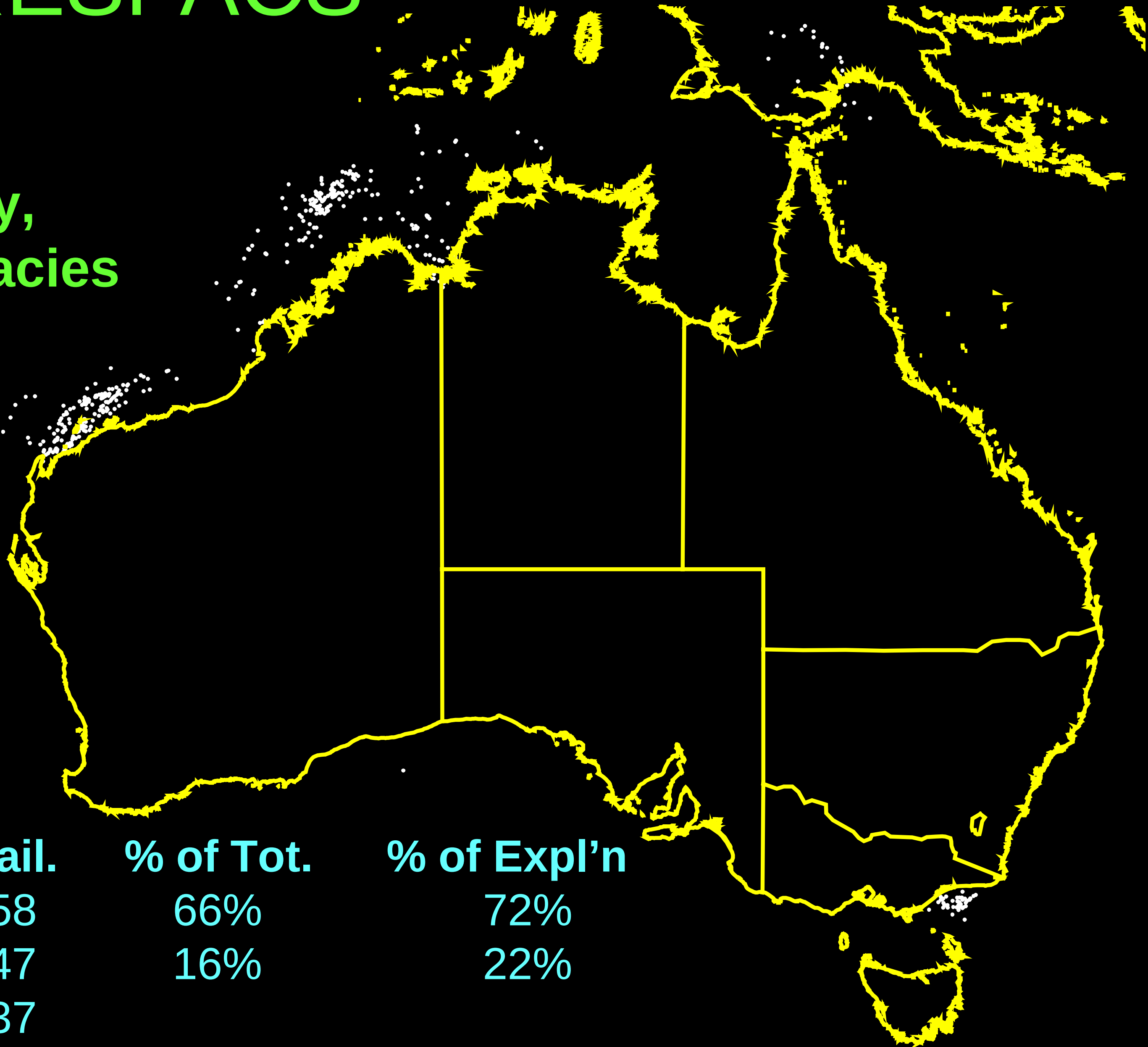
REGION	Avail.	% of Tot.	% of Expl'n
NW Shelf	467	77%	80%
SE Margin	238	78%	80%
Papuan	37		

Wells in RESFACS

Total = 486

October 1998

Shows, Porosity, Permeability, Facies

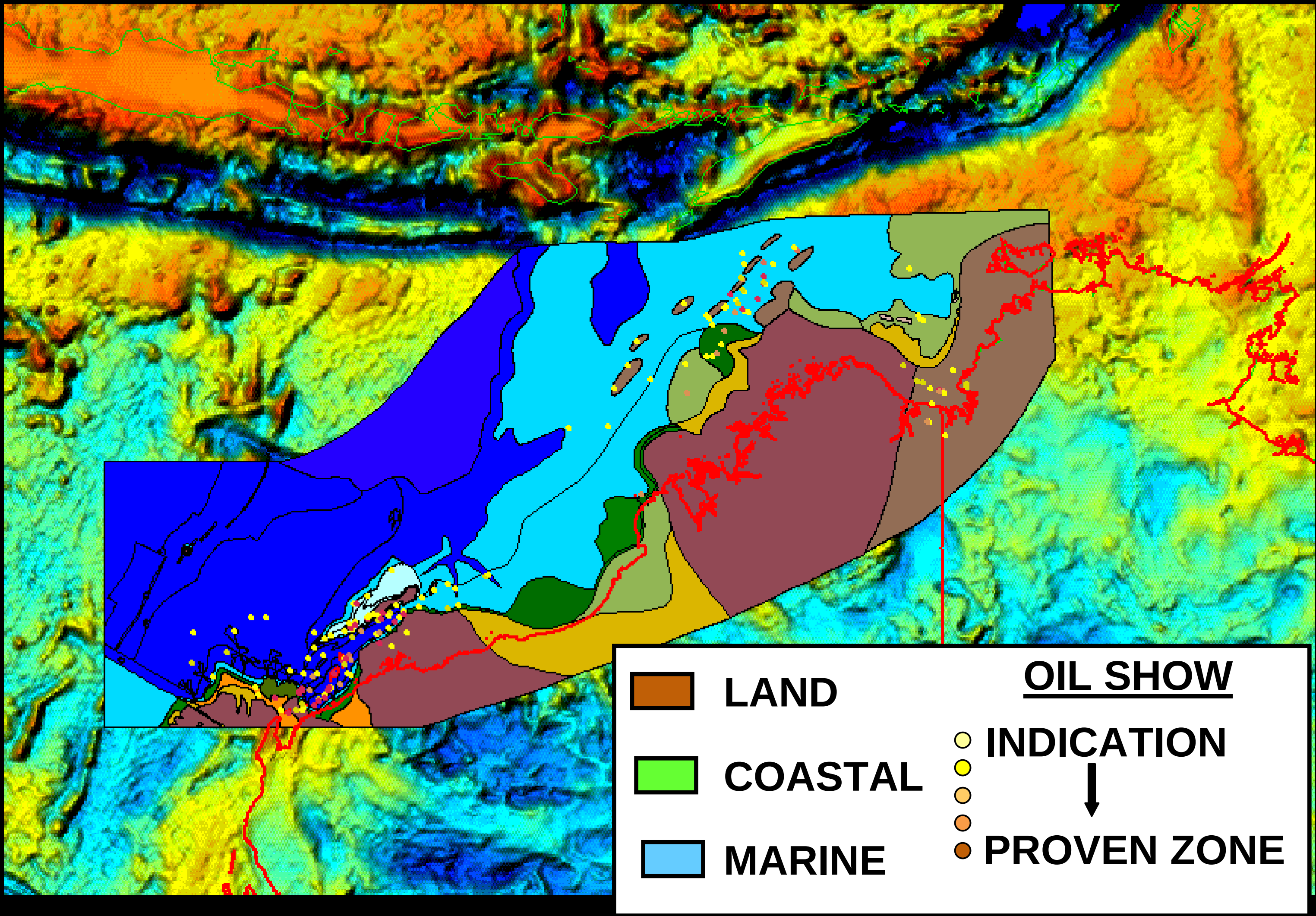


REGION	**Avail.**	**% of Tot.**	**% of Expl'n**
NW Shelf	358	66%	72%
SE Margin	47	16%	22%
Papuan	37		

DESIGN INFLUENCES

- Scale at which AGSO works (regional + play vs prospect)

North West Shelf Early Cretaceous Palaeogeography overlying gravity image



DESIGN INFLUENCES

- Scale at which AGSO works (regional + play vs prospect)
- technical competency of data capture for the data model for each discipline (confidence levels)

Confidence Levels for all rows of Interpretive Data

(eg picks for a Biostratigraphic zone in a well)

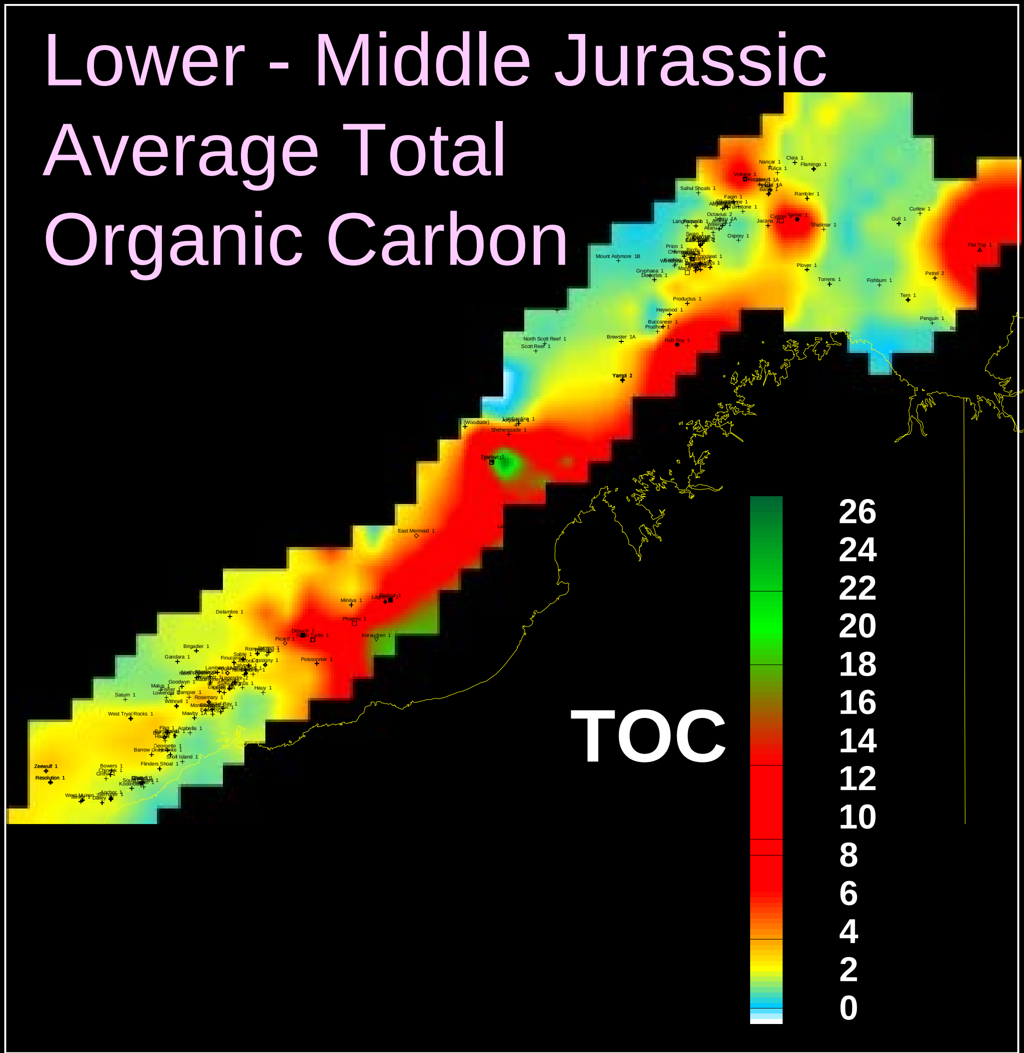
- 1 = high confidence
- 5 = very low confidence

- High diversity assemblage; many index fossils
  : user must honor it :
- Low diversity, no index fossils
  : user free to vary if inconsistent with other data - eg seismic:

DESIGN INFLUENCES

- Scale at which AGSO works (regional + play vs prospect)
- technical competency of data capture for the data model for each discipline (confidence levels)
- to allow processing of data using geologically intelligent application systems (TSS)

TIME SERIES SEARCHING (TSS)

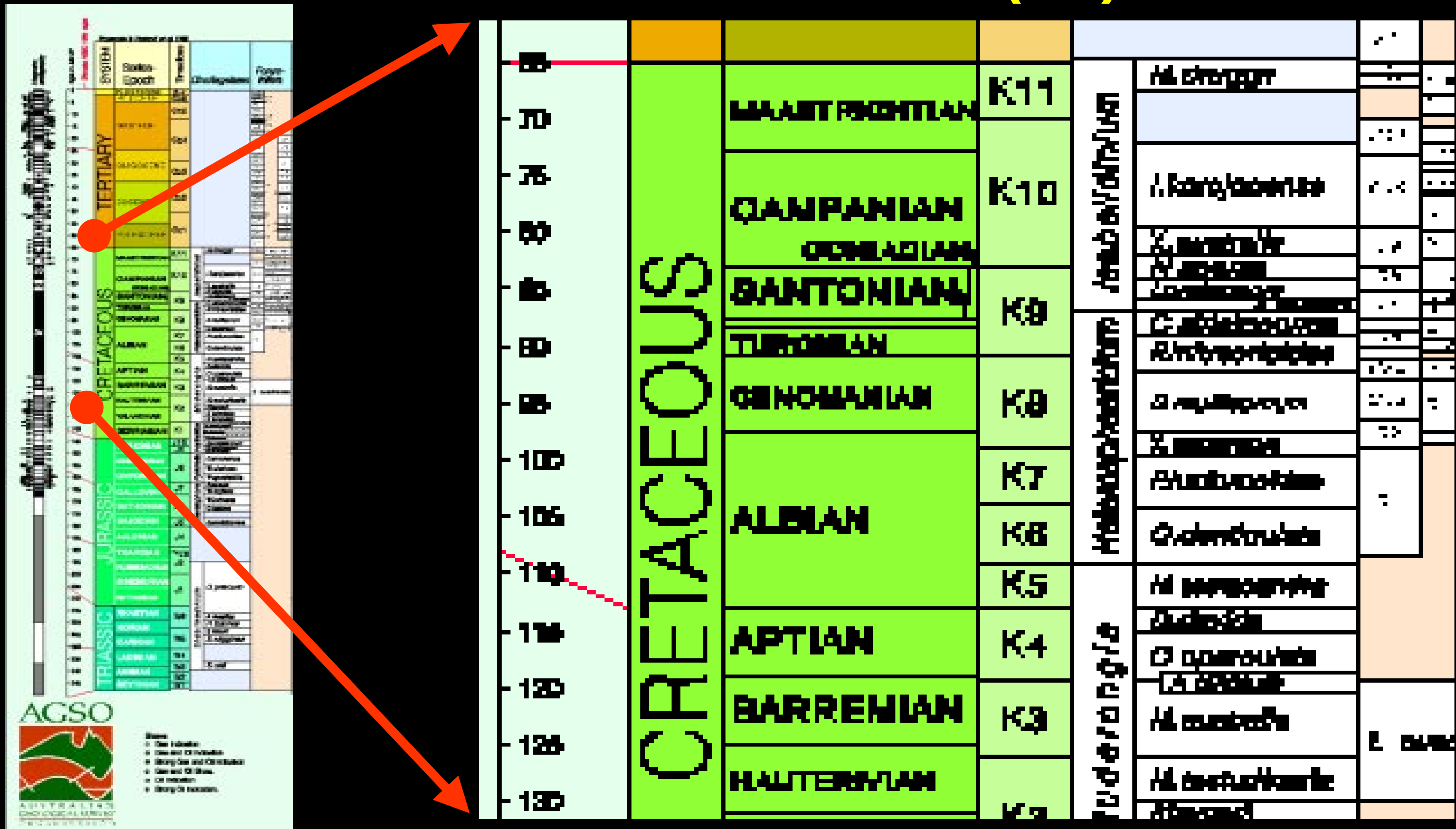


- Ability to access/retrieve geoscience data based on its biostratigraphic or radiometric age in millions of years (Ma)

DESIGN INFLUENCES

- Scale at which AGSO works (regional + play vs prospect)
- technical competency of data capture for the data model for each discipline (confidence levels)
- to allow processing of data using geologically intelligent application systems (TSS)
- produce on demand products (biozonation charts)

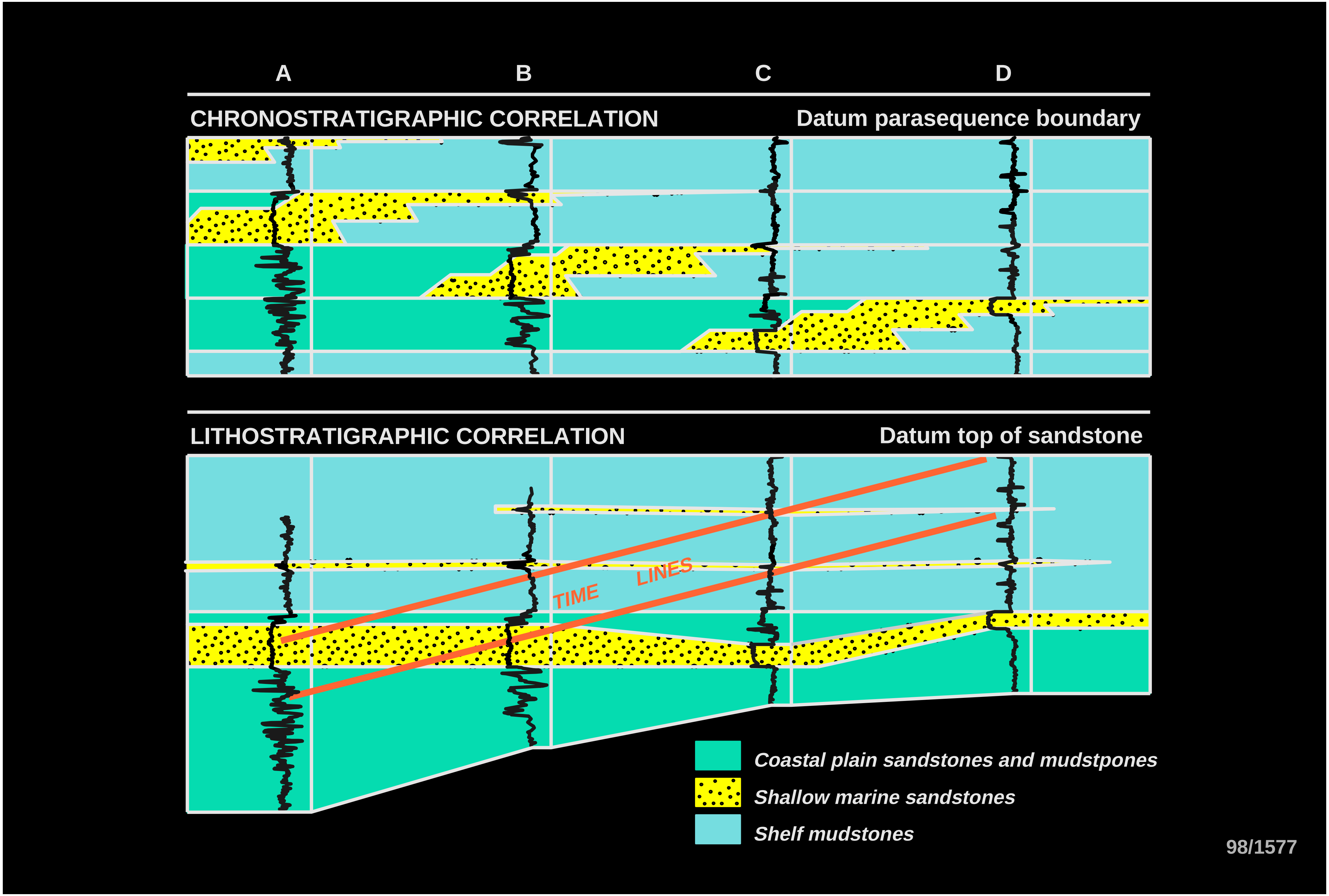
BIOSTRATIGRAPHIC ZONATION CHART IN MILLIONS OF YEARS (Ma)



Macro’s in Microstation access data in Oracle tables and draw the chart

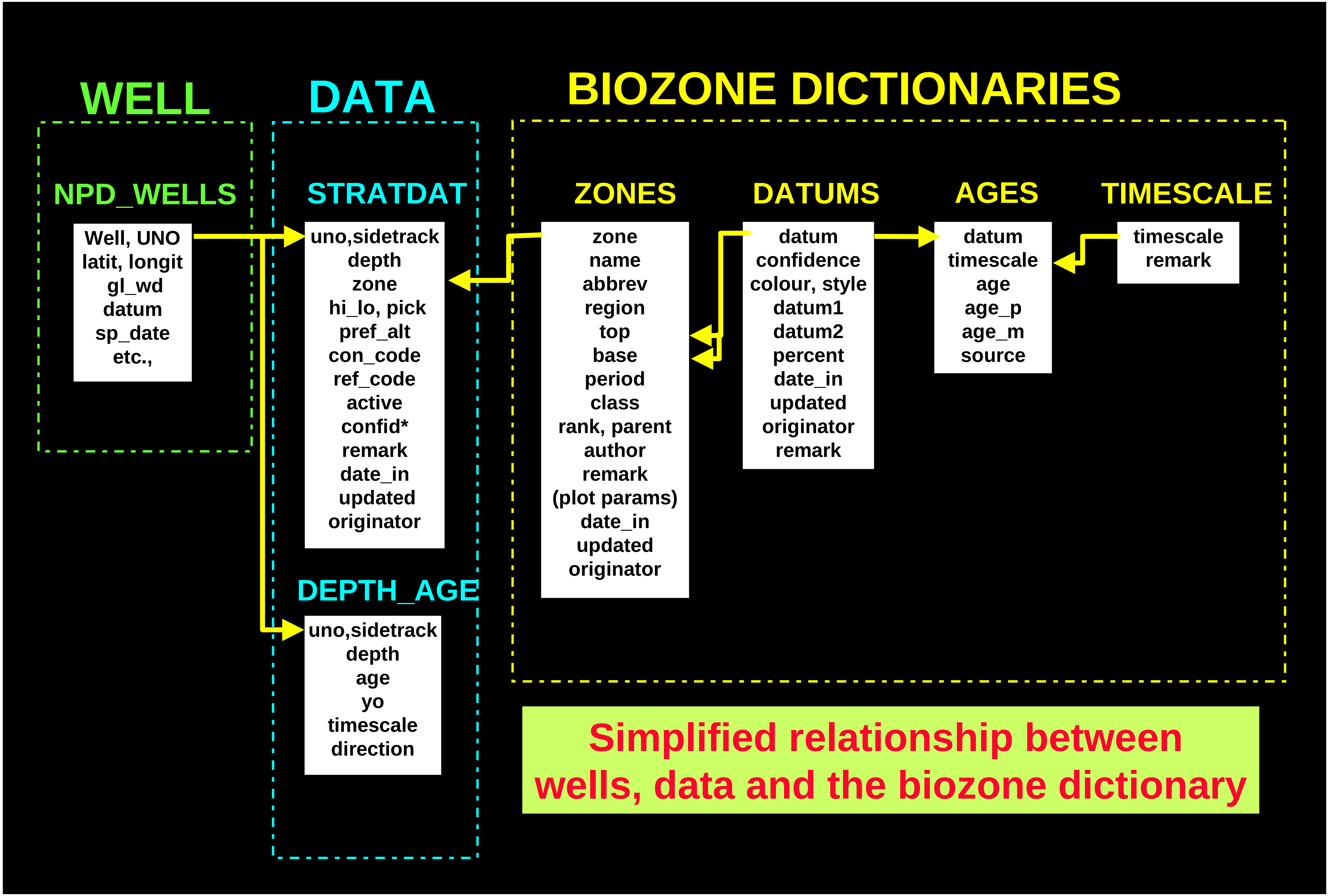
Biostratigraphy and TSS

- Micropalaeontology emerged in late 1950’s
- North America well correlations are lithostratigraphic based (formations - diachronous)
- Australian well correlations are biostratigraphic based (biozones - time equivalent)

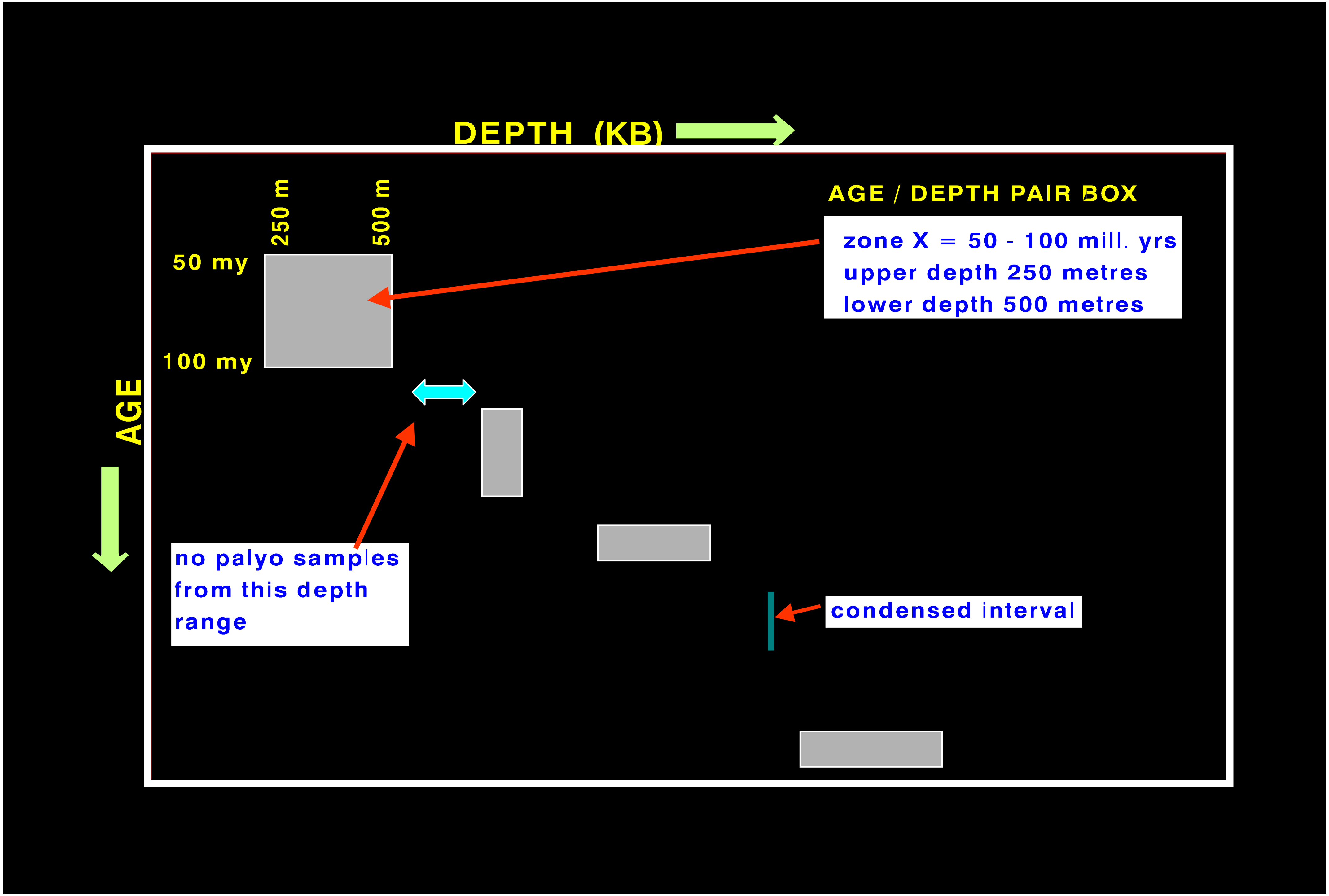

A
B
C
D
CHRONOSTRATIGRAPHIC CORRELATION
Datum parasequence boundary
LITHOSTRATIGRAPHIC CORRELATION
Datum top of sandstone
TIME LINES
Coastal plain sandstones and mudstpones
Shallow marine sandstones
Shelf mudstones
98/1577

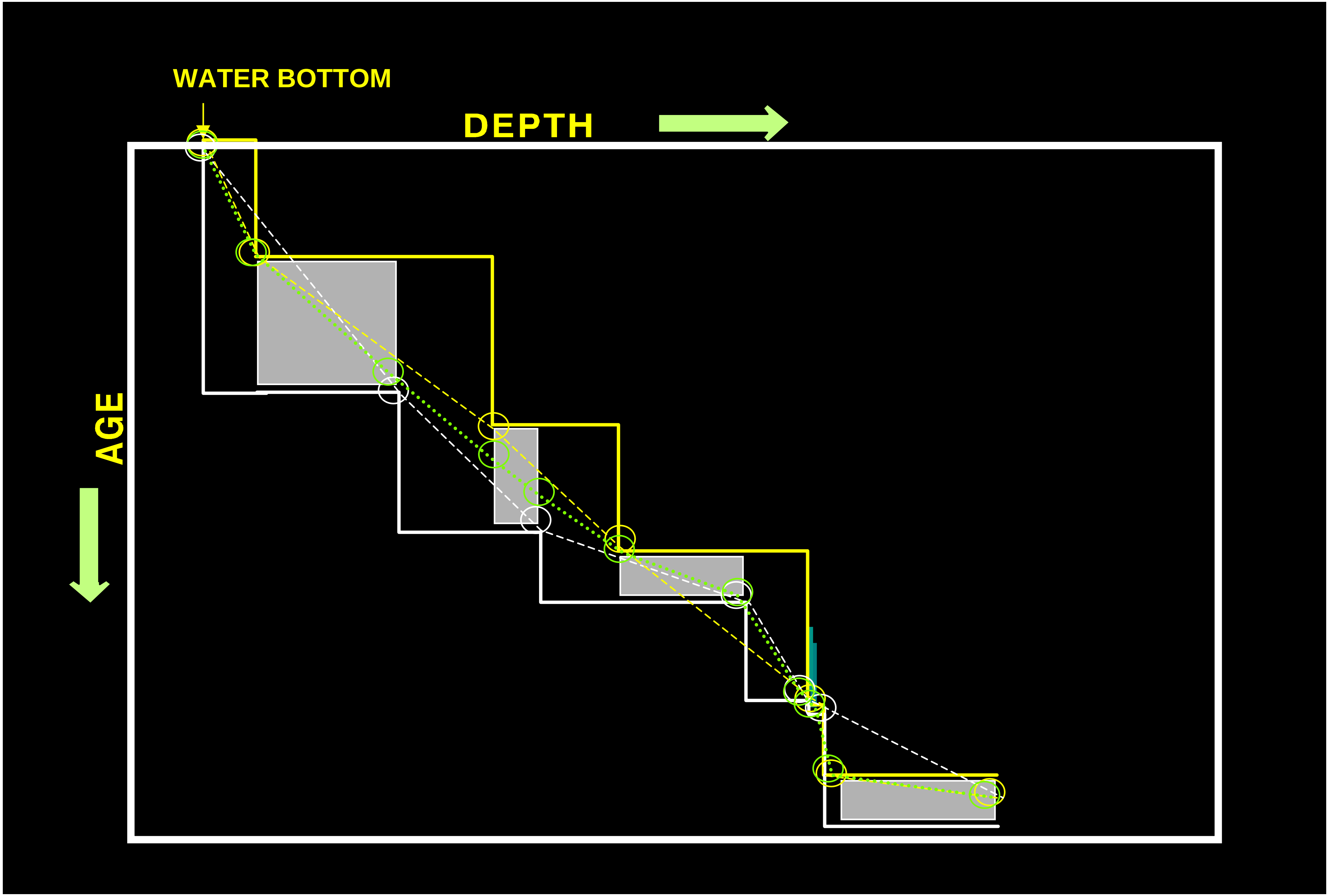
STRATDAT

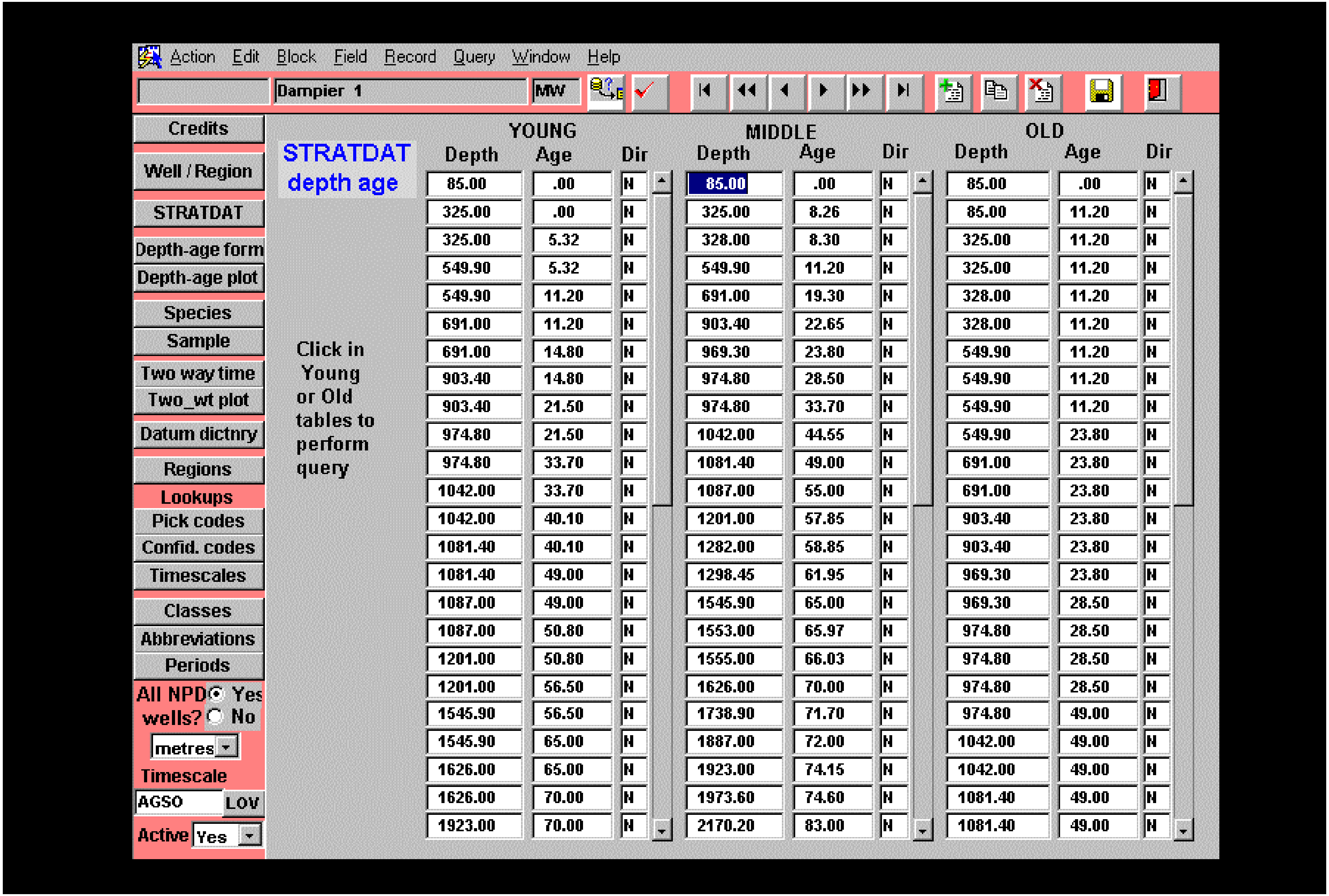
- Interpreted biozone picks in each well ; eg depth, zonename, high or low, confidence, sample type, etc
- each biozone in lookup table with its relative age in millions of years for range of radiometric timescales ; eg *pseudoceratium iehiense*, high 140 Ma, low 144 Ma, AGSO95 timescale



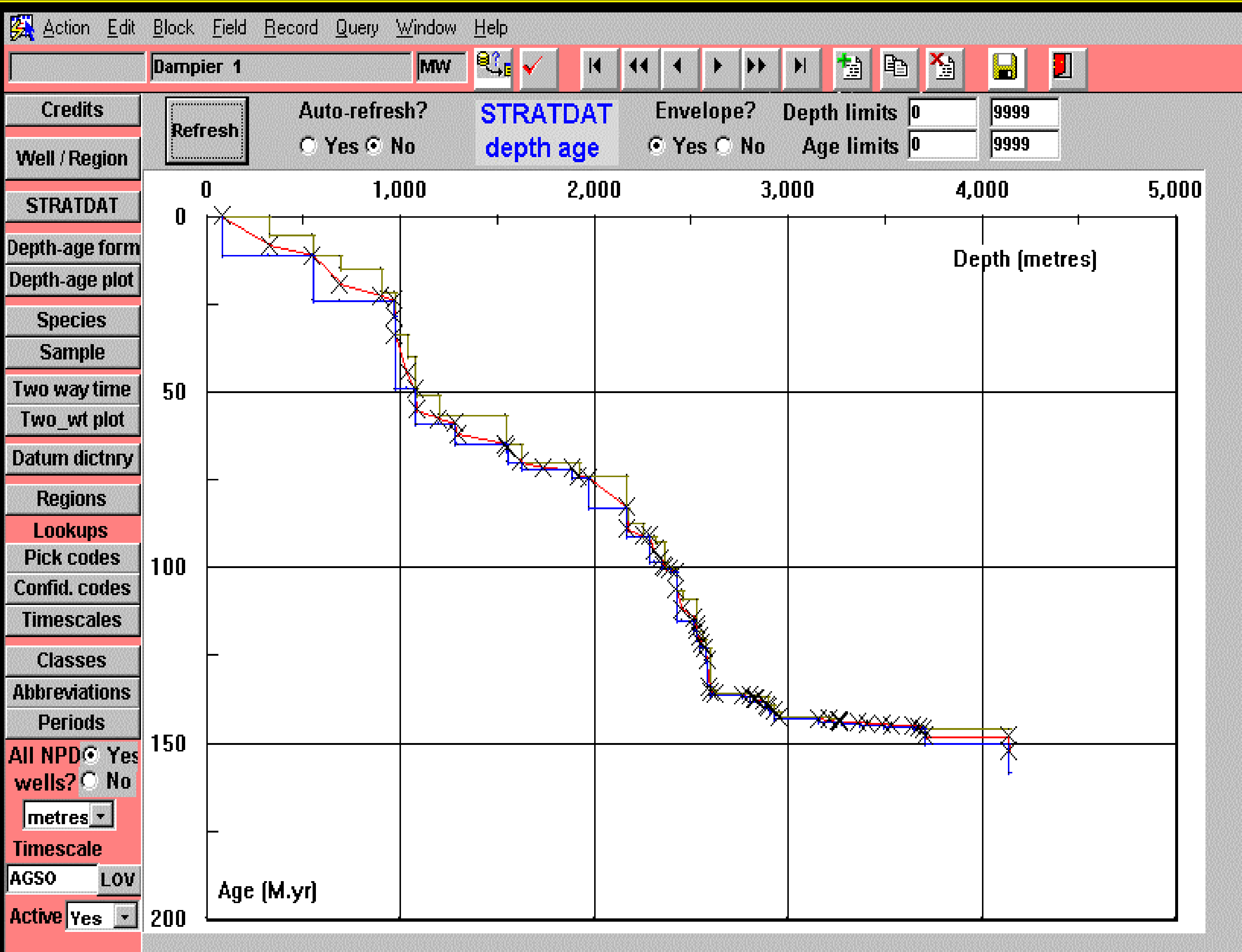
Simplified relationship between wells, data and the biozone dictionary


DEPTH (KB)
AGE
250 m
500 m
50 my
100 my
AGE / DEPTH PAIR BOX
zone X = 50 - 100 mill. yrs
upper depth 250 metres
lower depth 500 metres
no palyo samples
from this depth
range
condensed interval

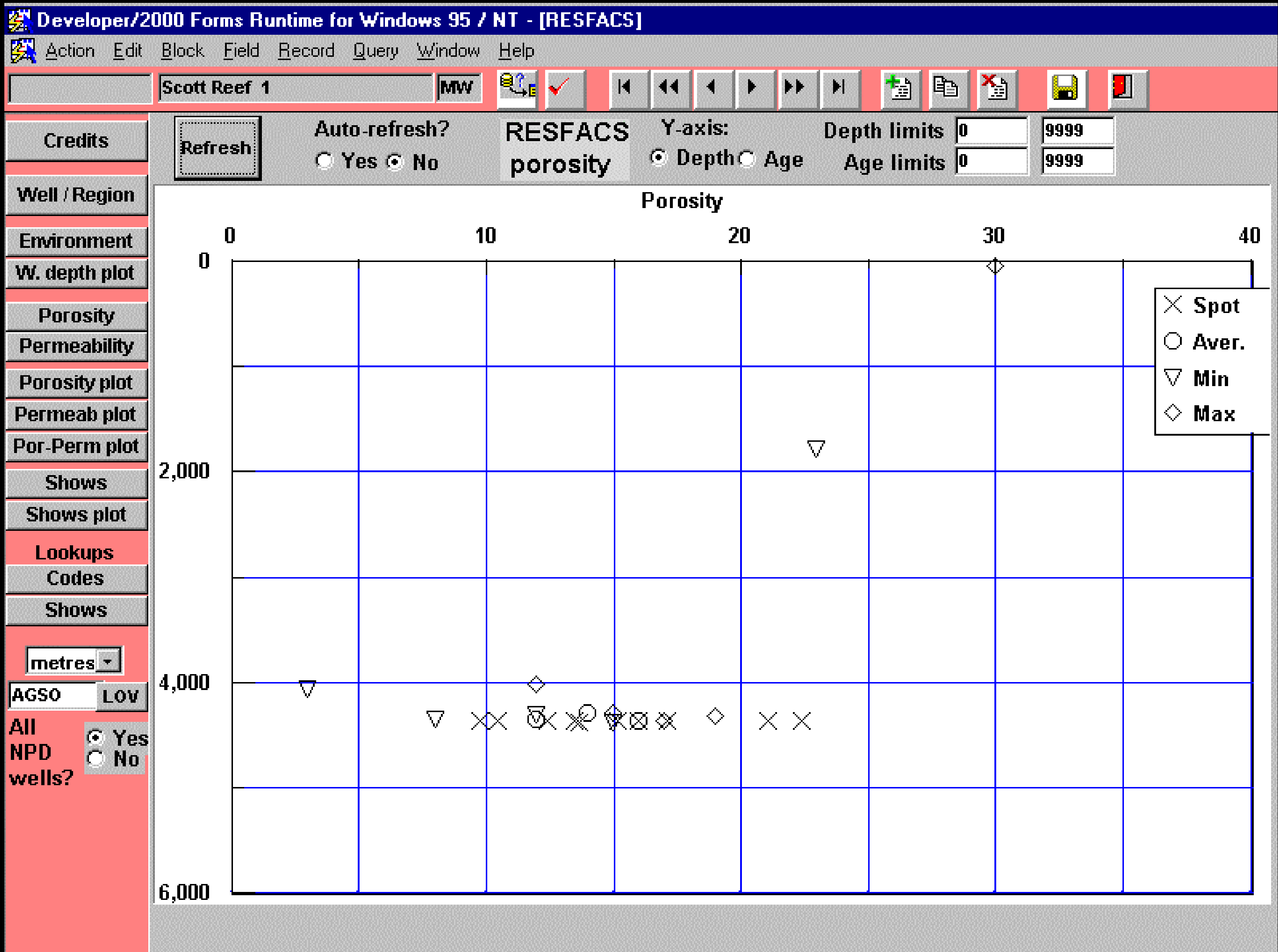

WATER BOTTOM
DEPTH
AGE



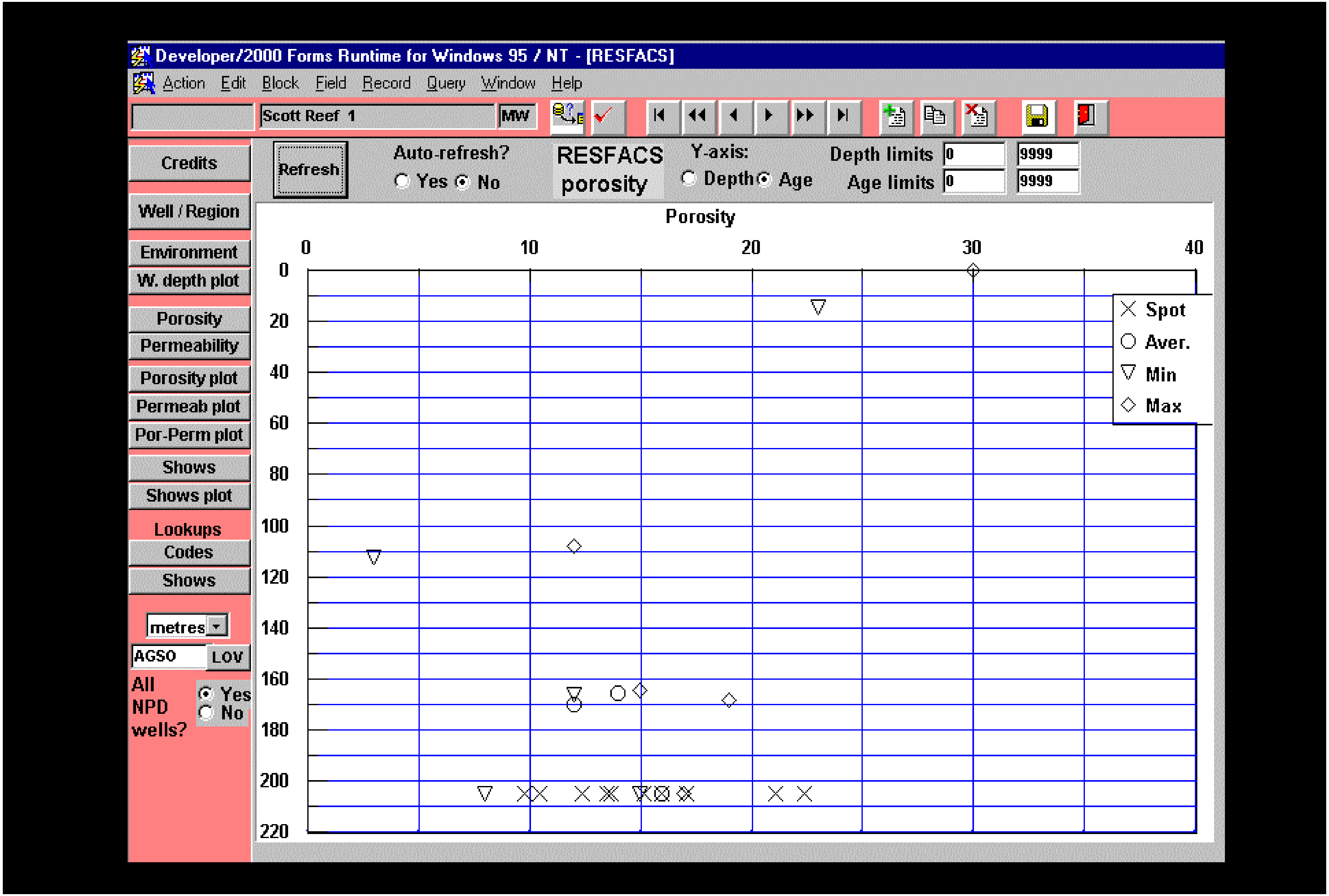
YOUNG			MIDDLE			OLD		
Depth	Age	Dir	Depth	Age	Dir	Depth	Age	Dir
85.00	.00	N	85.00	.00	N	85.00	.00	N
325.00	.00	N	325.00	8.26	N	85.00	11.20	N
325.00	5.32	N	328.00	8.30	N	325.00	11.20	N
549.90	5.32	N	549.90	11.20	N	325.00	11.20	N
549.90	11.20	N	691.00	19.30	N	328.00	11.20	N
691.00	11.20	N	903.40	22.65	N	328.00	11.20	N
691.00	14.80	N	969.30	23.80	N	549.90	11.20	N
903.40	14.80	N	974.80	28.50	N	549.90	11.20	N
903.40	21.50	N	974.80	33.70	N	549.90	11.20	N
974.80	21.50	N	1042.00	44.55	N	549.90	23.80	N
974.80	33.70	N	1081.40	49.00	N	691.00	23.80	N
1042.00	33.70	N	1087.00	55.00	N	691.00	23.80	N
1042.00	40.10	N	1201.00	57.85	N	903.40	23.80	N
1081.40	40.10	N	1282.00	58.85	N	903.40	23.80	N
1081.40	49.00	N	1298.45	61.95	N	969.30	23.80	N
1087.00	49.00	N	1545.90	65.00	N	969.30	28.50	N
1087.00	50.80	N	1553.00	65.97	N	974.80	28.50	N
1201.00	50.80	N	1555.00	66.03	N	974.80	28.50	N
1201.00	56.50	N	1626.00	70.00	N	974.80	28.50	N
1545.90	56.50	N	1738.90	71.70	N	974.80	49.00	N
1545.90	65.00	N	1887.00	72.00	N	1042.00	49.00	N
1626.00	65.00	N	1923.00	74.15	N	1042.00	49.00	N
1626.00	70.00	N	1973.60	74.60	N	1081.40	49.00	N
1923.00	70.00	N	2170.20	83.00	N	1081.40	49.00	N

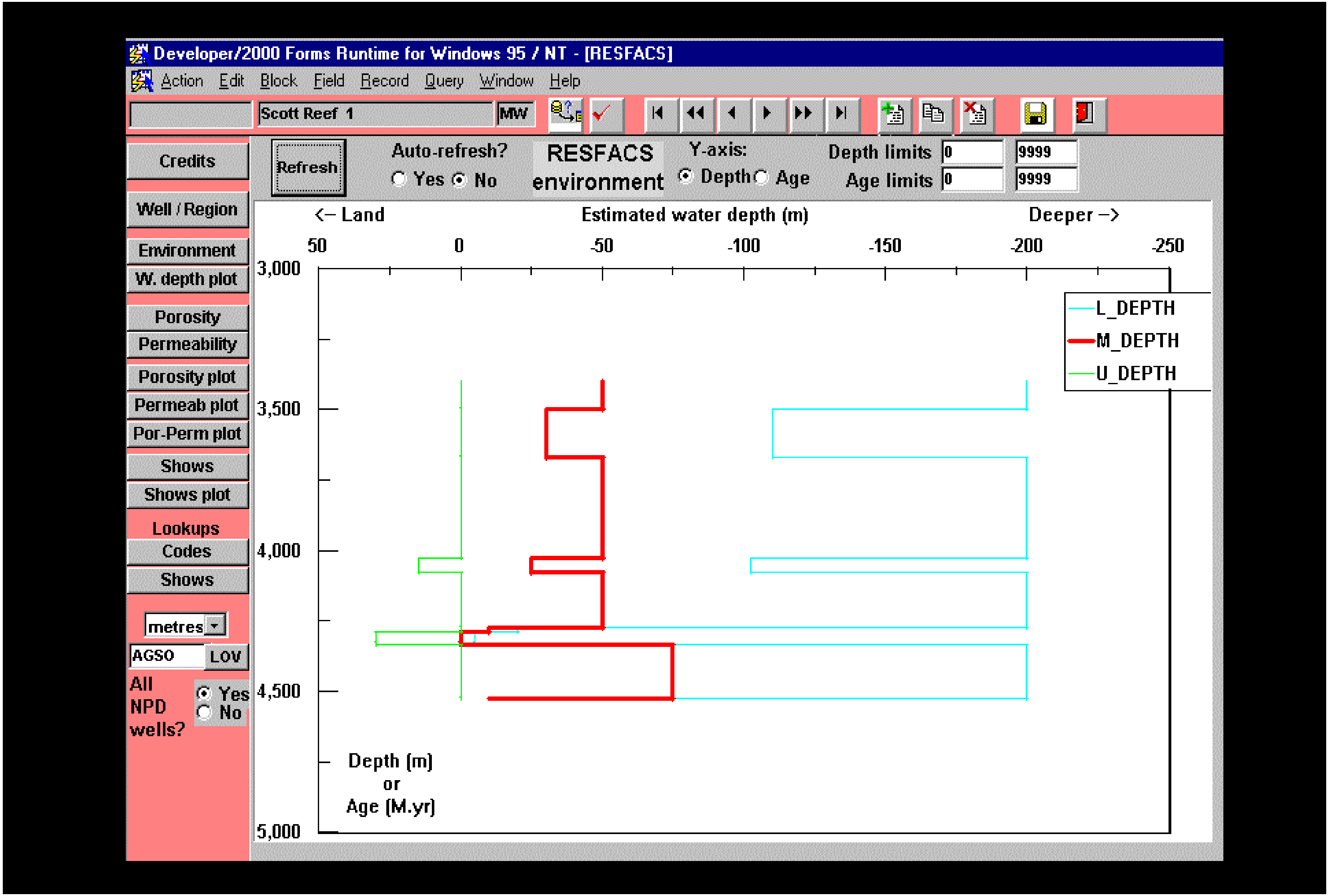


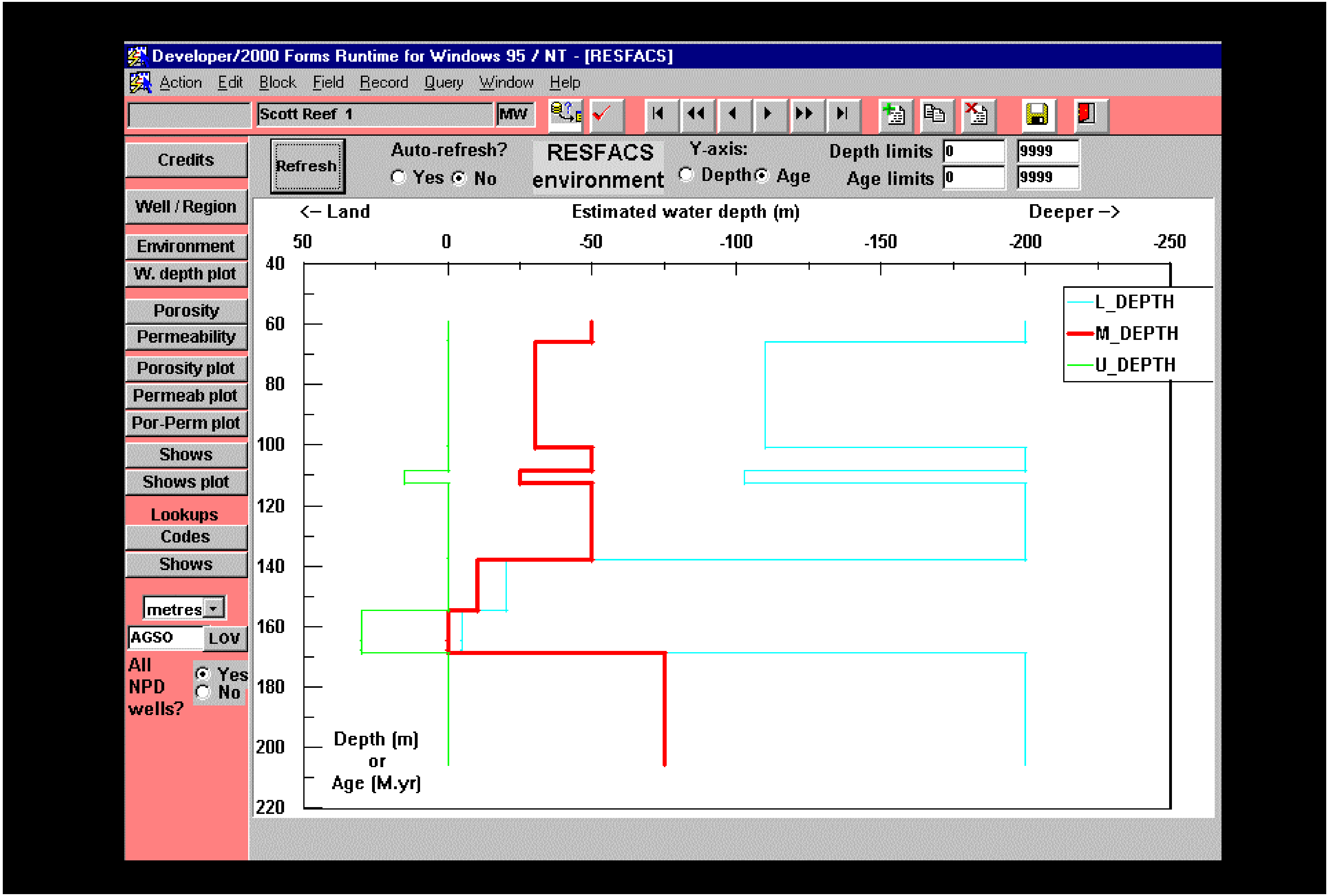
Action Edit Block Field Record Query Window Help
Dampier 1
MW
Credits
Well / Region
STRATDAT
Depth-age form
Depth-age plot
Species
Sample
Two way time
Two_wt plot
Datum dictnry
Regions
Lookups
Pick codes
Confid. codes
Timescales
Classes
Abbreviations
Periods
All NPD wells? Yes No
metres
Timescale
AGSO
LOV
Active Yes
Refresh
Auto-refresh?
Yes No
STRATDAT
depth age
Envelope?
Yes No
Depth limits 0 9999
Age limits 0 9999
0
1,000
2,000
3,000
4,000
5,000
Depth (metres)
0
50
100
150
200
Age (M.yr)



Developer/2000 Forms Runtime for Windows 95 / NT - [RESFACS]
Action Edit Block Field Record Query Window Help
Scott Reef 1
MW
Credits
Well / Region
Environment
W. depth plot
Porosity
Permeability
Porosity plot
Permeab plot
Por-Perm plot
Shows
Shows plot
Lookups
Codes
Shows
metres
AGSO
LOV
All NPD wells?
Yes
No
Refresh
Auto-refresh?
Yes
No
RESFACS porosity
Y-axis:
Depth
Age
Depth limits
Age limits
0
9999
0
9999
Porosity
0
10
20
30
40
0
2,000
4,000
6,000
Spot
Aver.
Min
Max

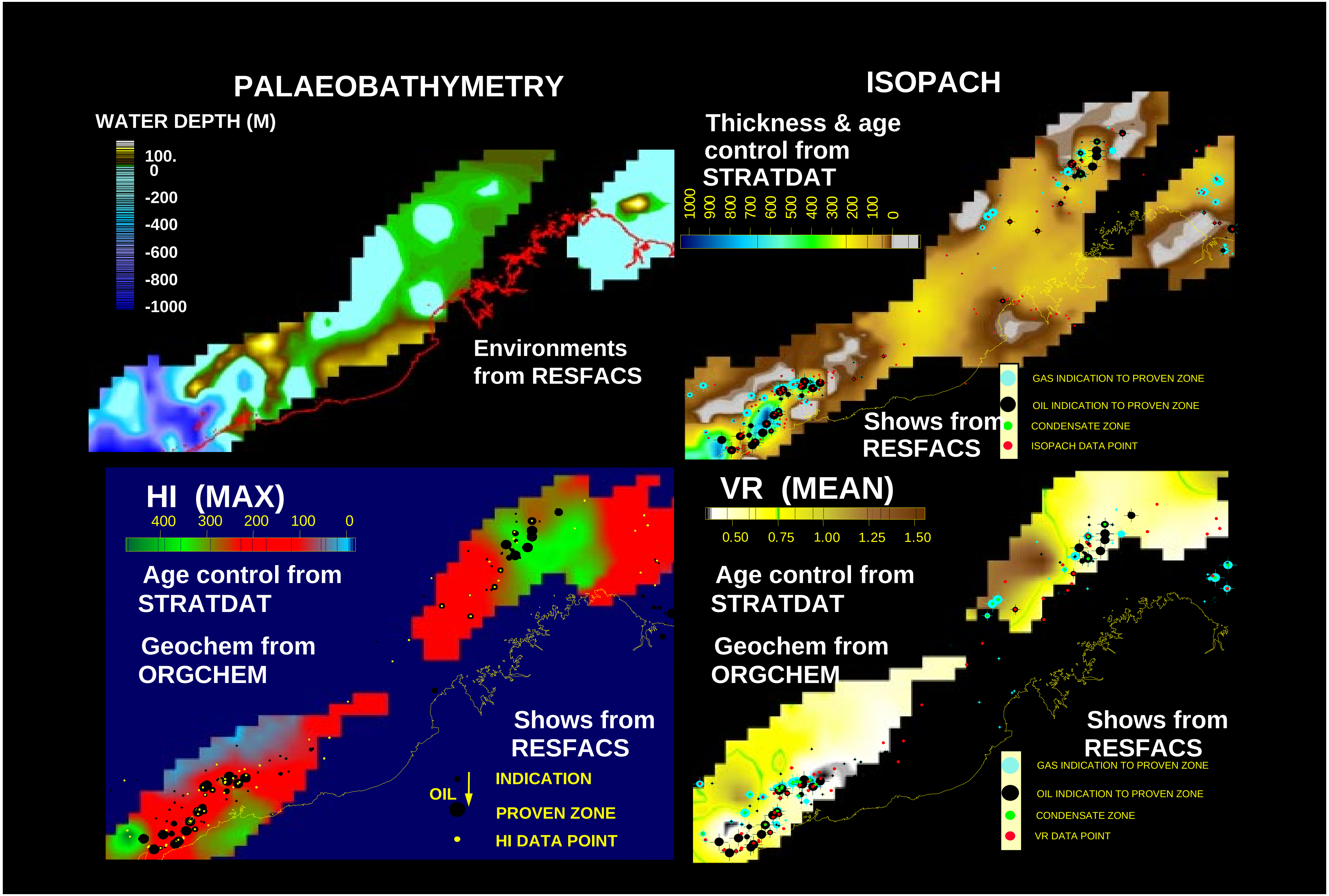

Developer/2000 Forms Runtime for Windows 95 / NT - [RESFACS]
Action Edit Block Field Record Query Window Help
Scott Reef 1
MW
Credits
Well / Region
Environment
W. depth plot
Porosity
Permeability
Porosity plot
Permeab plot
Por-Perm plot
Shows
Shows plot
Lookups
Codes
Shows
metres
AGSO
LOV
All NPD wells?
Yes
No
Refresh
Auto-refresh?
Yes No
RESFACS porosity
Y-axis:
Depth Age
Depth limits 0 9999
Age limits 0 9999
Porosity
0 10 20 30 40
0 20 40 60 80 100 120 140 160 180 200 220
Spot
Aver.
Min
Max


Developer/2000 Forms Runtime for Windows 95 / NT - [RESFACS]
Action Edit Block Field Record Query Window Help
Scott Reef 1
MW
Credits
Well / Region
Environment
W. depth plot
Porosity
Permeability
Porosity plot
Permeab plot
Por-Perm plot
Shows
Shows plot
Lookups
Codes
Shows
metres
AGSO
LOV
All NPD wells?
Yes
No
Refresh
Auto-refresh?
Yes
No
RESFACS environment
Y-axis:
Depth
Age
Depth limits
0
9999
Age limits
0
9999
<- Land
Estimated water depth (m)
Deeper ->
50
0
-50
-100
-150
-200
-250
3,000
3,500
4,000
4,500
5,000
L_DEPTH
M_DEPTH
U_DEPTH
Depth (m) or Age (M.yr)


Developer/2000 Forms Runtime for Windows 95 / NT - [RESFACS]
Action Edit Block Field Record Query Window Help
Scott Reef 1
MW
Credits
Well / Region
Environment
W. depth plot
Porosity
Permeability
Porosity plot
Permeab plot
Por-Perm plot
Shows
Shows plot
Lookups
Codes
Shows
metres
AGSO
LOV
All NPD wells?
Yes
No
Refresh
Auto-refresh?
Yes
No
RESFACS environment
Y-axis:
Depth
Age
Depth limits
0
9999
Age limits
0
9999
<- Land
Estimated water depth (m)
Deeper ->
50
0
-50
-100
-150
-200
-250
40
60
80
100
120
140
160
180
200
220
L_DEPTH
M_DEPTH
U_DEPTH
Depth (m) or Age (M.yr)

TSS Products

- Isopach maps
- top/base structure maps
- contour maps of av./max./min. values for any analytical measurement (TOC, VR, HI, porosity, permeability, palaeobathymetry etc)
- graphs of analytical measurements (porosity in Timor Sea from Upper Jurassic reservoirs - age/depth)

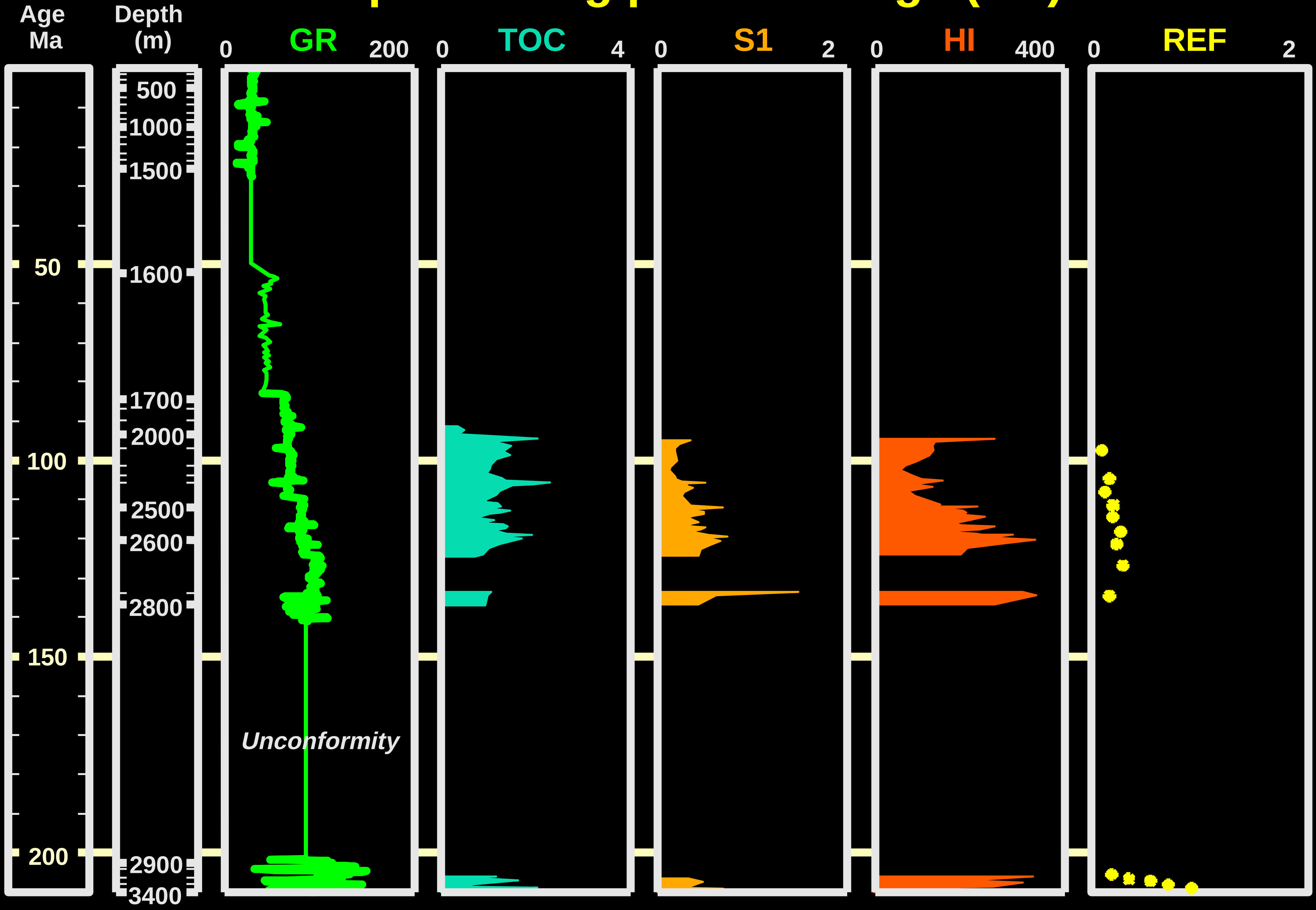


PALAEOBATHYMETRY
WATER DEPTH (M)
100.
0
-200
-400
-600
-800
-1000
Environments from RESFACS
ISOPACH
Thickness & age control from STRATDAT
1000 900 800 700 600 500 400 300 200 100 0
Shows from RESFACS
GAS INDICATION TO PROVEN ZONE
OIL INDICATION TO PROVEN ZONE
CONDENSATE ZONE
ISOPACH DATA POINT
HI (MAX)
400 300 200 100 0
Age control from STRATDAT
Geochem from ORGCHEM
Shows from RESFACS
OIL
INDICATION
PROVEN ZONE
HI DATA POINT
VR (MEAN)
0.50 0.75 1.00 1.25 1.50
Age control from STRATDAT
Geochem from ORGCHEM
Shows from RESFACS
GAS INDICATION TO PROVEN ZONE
OIL INDICATION TO PROVEN ZONE
CONDENSATE ZONE
VR DATA POINT

TSS Products

- Recalibration of plots against age (millions of years) instead of depth or two-way time (log cross-sections, seismic {Vail type displays})

Composite Log plotted in Age (Ma)



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SOME New Database Research Requirements & Issues

- Deviant (Deviated wells & Measured sections ++)
- Sniffer (Hydrocarbon seepage)
- UV (Ultra violet response of oil)
- GOI (Hydrocarbon fluid inclusions)
- Lithology (log vs outcrop issues)
- Seismic (acquisitions + data + interpretations)
- AQUIS Marine Ports (MITCRC) (Ballast water, currents, sediment, etc)
- Laboratories (Paleo, Geochem, etc)

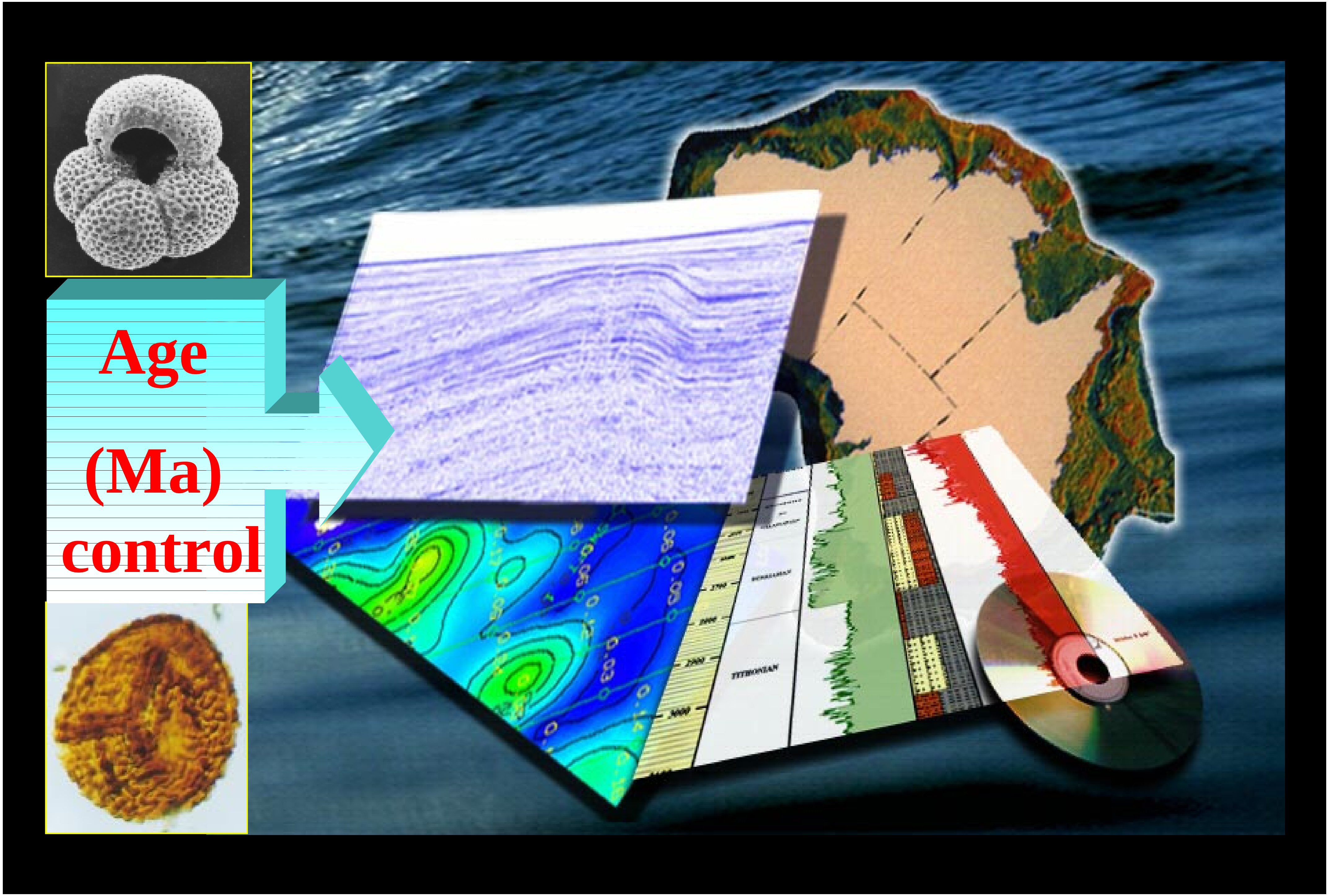
Management

Current Application Developments

- Loaders to applications (Geolog, Landmark, Geoquest, etc)
- MD to TVD
- TSS into Minerals
- Stratnames to Stratdat
- Sub-sampling lithology
- Oracle Forms 3 to 4.5 to 5
- Capture lab machine data directly into databases

Future / Ongoing Objectives

- Contribute to standards
- Expand TSS concepts / functionality
- Remap PEDIN (NPD) to be more consistent with POSC/PPDM
- AGSO corporate model → long term
- Deploy databases over Web (internal then ? External)


Age
(Ma)
control
TITHONIAN

FracSIS-A three-dimensional spatial information system for the geosciences

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Abstract
Geoscientific data is currently stored and manipulated in a wide variety of software packages. These software packages use proprietary file formats and much of the information contained cannot be transferred between systems due to incompatibilities. Whilst these systems commonly have excellent facilities for modelling and data processing they are often difficult to utilise when simply investigating the data. Few systems treat the models as 3D spatial objects with geoscientific semantics; rather they utilise geometry as is done in standard CAD systems, often without the semantics. There are no tools for visually exploring and interacting with the geoscientific information, a task vital to effective analysis. This lack of integration and limited support for interacting with the information hampers the ability to combine the strengths of each package and support effective investigation processes. Fractal Graphics has been addressing these issues by developing FracSIS.

FracSIS, is Fractal Graphics' next generation Geoscientific Information Management System. FracSIS is an integrated suite of software modules. These modules are designed to complement existing geoscientific software packages and provide information management for medium to large datasets (10's of Gigabytes to 10's of Terabytes). The primary goals are:

1. To provide a single, unified storage facility for geoscientific information that supports data interchange to and from other software packages.
2. To provide a visual interface to the unified data which supports effective decision making processes for the geoscientific community.

FracSIS, provides persistent data storage, data (including 3D spatial) query, and data mining facilities. This is a core technology and provides the basis for data storage, integration, and transfer of information. Using FracSIS it will be possible to store all geoscientific information required in a single, well-organised database. This module also provides methods for communication of this information across a network and to disparate software packages. By doing this FracSIS will help to reduce duplicate or redundant information and provide a consistency of representation across applications and users. The resulting increase in accuracy and availability will improve geoscientific applications. Several new technologies are being utilised in the development of FracSIS including an Object Oriented Database, full 3D spatial data model with query support, scalable distributed object model for high performance database handling, interactive geoscientific visualisation, and an open architecture for third party product interfaces.

1 Introduction

In the mining and exploration industry, the collection and interpretation of geological data provides geologists with the information required to make judgements on where valuable minerals are likely to be found. In recent decades, the technology and processes involved in the collection and interpretation of geologically relevant data have improved dramatically. However, limitations in the software widely used and the way in which information is managed result in reduced productivity missed opportunities and greater expense to the industry.

The software applications widely used in the exploration and mining industry suffer significant limitations. In particular, the applications:

- generally provide an extensive range of (often overlapping) information modelling functions, but do not focus on the management and interpretation of that information;

- do not inter-operate well with other packages;

- do not adequately manage and manipulate large multi-gigabyte data-sets;

Poor management of large databases of spatial geological data is becoming an increasingly relevant problem because the technology to manage and store information is not keeping up with the technology used to collect it. Some companies have large databases of spatial geoscientific data that cannot be analysed because there are no convenient methods available to:

1. Manage this data; and,

2. Interpret and analyse the data in a “geologically relevant” manner.

The sheer amount of data that has already been obtained and archived is, in some cases, immense. In addition, data collection technology is continuing to improve (eg. improved sampling resolution from satellite surveying, new methods for analysing drill hole cores) and hence the volume of data being collected is increasing rapidly.

This argument can be extended to the general geoscientific industry with in Australia and worldwide. There is a need for an integrated, extendable, and open standard data model for the geosciences. A data model of this type, with supporting applications, would simplify information interchange, reporting and understanding. It would allow integration of a variety of geoscientific information into a single data repository allowing far better understanding of the issues being investigated. In addition, the unified database of information would better support the cross-discipline approach being employed in many scientific endeavours.

FracSIS is being developed as a core component in the solution of these problems. In particular FracSIS provides the following high-level operations:

- Effective management and storage of large multi-gigabyte sets of geological information including: version history; derived data history; user-configurable working sets; flexible data consistency checking; geological attribute management; unified data storage; support for visualisation, full 3 dimensional topology, and data mining applications.

- Inter-operability with existing and future application programs through legacy and native interfaces.

- Support for spatial and a-spatial queries of geological information.

FracSIS provides the core information system operations that are currently missing from otherwise powerful industry software packages. In addition, it provides an advanced data management system for use by future "FracSIS" aware applications.

2 Previous work

Fractal Graphics utilises a wide variety of existing software packages ranging from 2D GIS systems (ArcInfo, ER Mapper) and Mining CAD packages (Vulcan, Microstation) through to general scientific visualisation systems (IRIS Explorer). Each software package often has a particular strength at handling some types of data. As such, many projects require the use of multiple mining software packages.

Existing mining software packages provide facilities for data collection and manipulation. These systems are not unlike standard 3D CAD modelling tools. These software packages use proprietary file formats and much of the information contained cannot be transferred between systems due to incompatibilities. In addition, the primary task of these software packages is to create models, not to aid in making decisions. Whilst these systems often have excellent facilities for modelling they are often difficult to utilise in the decision-making process. Few systems treat the models as geology; rather they utilise geometry as is done in standard CAD systems. There are limited tools for visually exploring and interacting with the geological information, a task vital to effective interpretation of the geology.

Many of the available GIS systems provide support for information query and assist the decision making process. Visualisation of various data layers is possible and some packages allow a 3D view of height field data. It is difficult to integrate these GIS systems with other mining software packages due to the limitations in data types supported. Most significantly to the mining industry is the limitation to 2D information (possibly with elevation), there is little if any support for true 3D information.

This lack of integration and limited support for interacting with the information hampers the ability to combine the strengths of each package and support effective decision processes. Fractal Graphics has been addressing these issues by developing tools and processes that improve decision making. In-house development of file format conversion tools and the use of generic scientific visualisation software facilitated this process. When combined with existing mining software packages and the Fractal Graphics information management process the result is vastly improved communication and decision making. This innovative approach has made Fractal Graphics a successful and unique geological consultancy. Note that the approach is not to replace or unify all the different packages. Doing so would be counter productive since the reason for the variety is to make use of each packages strengths.

Increasing frustration at the lack of a single visualisation environment let to Fractal Graphics developing FracViewer. A state of the art visualisation system with a range of file format converters to enable data stored in disparate packages (eg. ER Mapper and Datamine) to be visualised in a single environment. The development of FracViewer inevitably led to the concept of FracSIS.

FracSIS is a core component, of Fractal Graphics' next generation Geological Information Management System. FracSIS is an extension of the work already completed by previous projects and is an integrated suite of software modules. These modules are designed to complement existing geoscientific software packages, not to compete with them. The primary goals are:

- ♦ To provide a single, unified storage facility for geological information that supports data interchange to and from other software packages.

- ♦ To provide a visual interface to the unified data which supports effective decision making processes for the mining industry.

It is important to note that FracSIS provides no support for 3D modelling. This functionality is well covered by existing mining software. Instead, the system is designed to support the integration and exploration of the information from these other systems.

3 System Concept

The external interfaces to FracSIS are designed to support four major areas of work-flow used by geologists (see Figure 1):

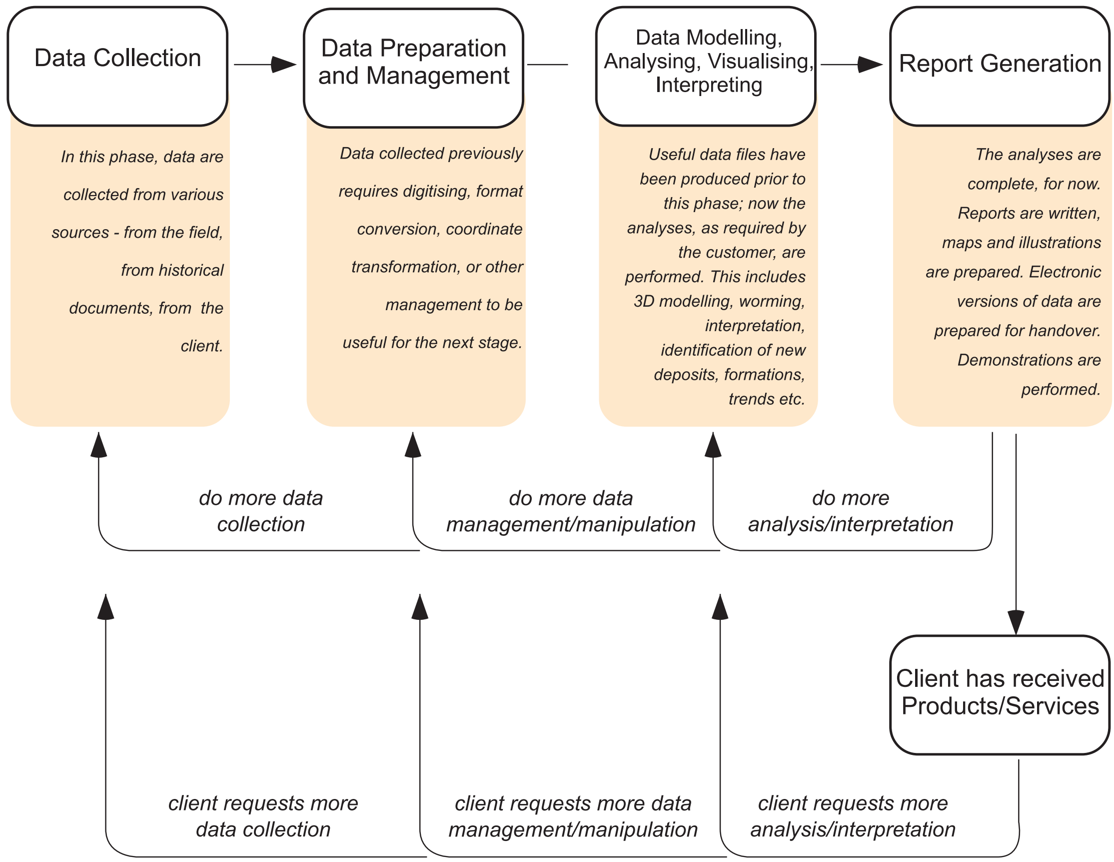

FIGURE 1. Four Major Areas of Workflow used by Geologists

a) Data collection

- This involves collation, verification and consistency checking of data collected from a wide variety of sources.

b) Data preparation and management

- Some data requires further processing to convert to digital form and transform to a common coordinate system. In addition logs of the history of data, versions of interpretation and the relationships between derived data and the data used to create it are also necessary.

c) Data analysis, visualisation and modelling

- This involves the creation of new derived data (eg. geological models), investigation of geological attributes, visualisation of multi-datatypes, etc. The primary goal of this area is to identify new features of interest.

d) Report generation

- Once the investigation is complete reports are published in many formats both electronically and on paper.

In its simplest form, FracSIS will act as an information repository to client applications with different software architectures – applications such as Vulcan will be able to use the system in this way. However, FracSIS will provide significantly more than just data storage and retrieval services to "FracApps," applications that have been built to take advantage of the services FracSIS provides. The dataflow between FracSIS and different client applications is summarised in Figure 2.

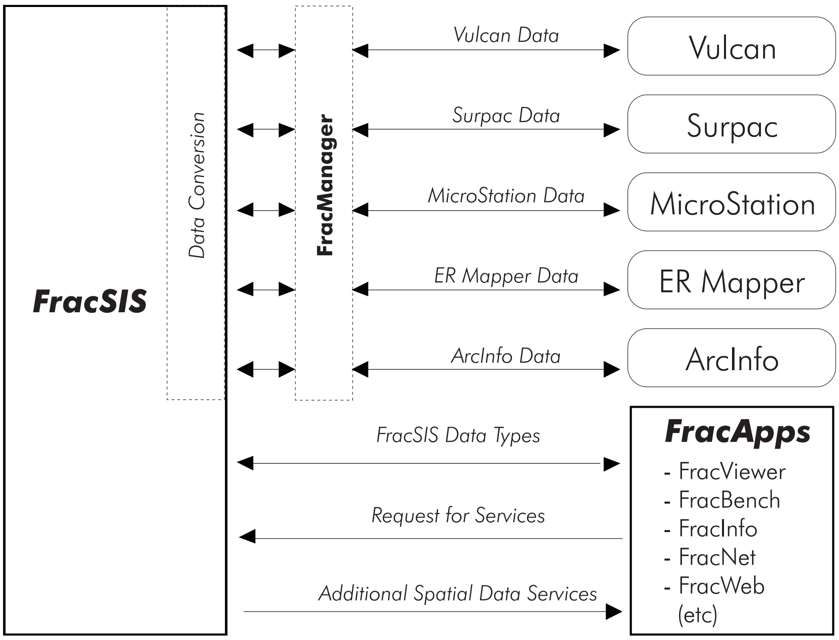

FIGURE 2. Dataflow between FracSIS and other Applications

4 Operational environment

FracSIS is a highly configurable application that can be deployed in a single-user PC configuration through to a complex multi-user heterogeneous environment serving the needs of an entire site or organisation. Furthermore, components of the system can be distributed across multiple systems over LAN, WAN or the Internet. The exact operational environment depends on the needs of the user, the size of the data set and the types of computing platforms on which the system is to run.

In this section the environment and operational modes for FracSIS will be described as might be deployed in a geological consulting service to the mineral and exploration industry. The expected database size is around 100 Gigabytes on-line at any one time, with archived data of 10 to 20 times that size. Integration of large amounts of raster imagery (ie. Satellite data, aerial photography) could substantially increase this data size. Computing facilities range from Windows PCs to UNIX Workstations and servers.

The operating scenarios for the consultancy fall loosely into four domains:

1. **Collecting data**: Data is collected from a wide variety of sources including: field surveys, drill hole data, digital terrain data, pit surveys, historical maps and reports, geological knowledge of the region. Some data may not be in digital form.

2. **Data Preparation and management**: This involves conversion of data to digital form, consistency checking, merging of disparate data sets, coordinate conversion, initial geological modelling.

3. **Data Modelling, Visualisation, Interpretation, and Analysis**: This domain is a core component of the creation of the geological model. The stages listed are iterated over as the geological model is updated and analysed for further information. Typically, geological modelling and interpretation are used to build increasingly detailed models of the geology and analysis performed to identify new features and deposits. Increasingly the scaling of digital data (ie pit mapping collected at 1:500 scale and integrated into a regional model at 1:250000 scale) is becoming a significant problem. Generally, specific tools are utilised depending on the data type to be analysed (eg. Magnetics data analysis using ER Mapper, drill hole interpretation using Vulcan). The resulting derived data sets are then brought into a visualisation tool suitable for viewing all the data types together (eg. FracViewer).

4. **Product delivery**: At the end of the analysis a report is produced showing the newly identified features along with supporting models and images. This report is generally produced as a combination of printed matter, electronic reports, and demonstrations to the client of the visualisation.

Multiple staff are involved in each domain and different computing platforms, suited to the task required, are utilised for the different operations. Figure 3 shows how FracSIS might be deployed along with computing platforms and expected client software systems.

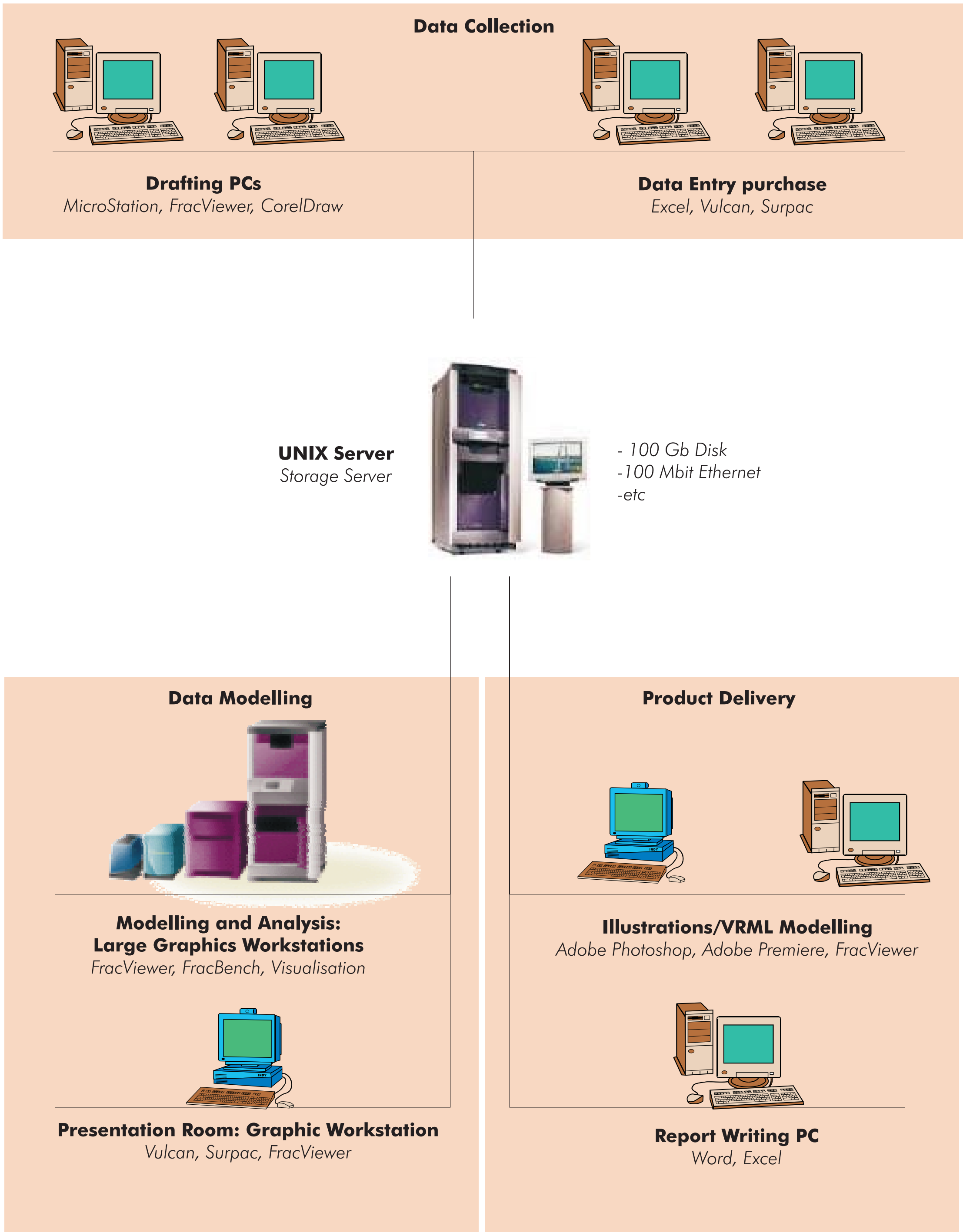

FIGURE 3. FracSIS Deployment

A UNIX (or NT) server acts as the repository for persistent data and provides a centralised location for administration and backup of the data. The various application servers are distributed onto the other machines and the server to match the performance and work requirements of the operating scenarios. For example, visualisation and analysis services are performed primarily on the powerful UNIX Graphics workstation, so the visualisation and computational geometry services are distributed there. Data conversion services are used universally in the organisation and perform better when high performance IO to the data exists. The data conversion application server is placed on the same machine as persistent storage to facilitate this. Client applications are distributed to the various machines depending on the usage of the primary user for the machine and the role they play with in the work-flow.

It is worth noting that all application servers are available to all client systems even though they may not be on the central server system. This means that although someone working on a report on a PC (Product delivery) is not running the visualisation services, they can still access those services on the UNIX Graphics workstation should they need that service.

The FracSIS environment scales with database size and number of users. Multiple copies of the same application server may be dynamically created depending on the number of users and available machines. This is also important for deployment in a single user environment where the less powerful system may not be able to support all application servers running simultaneously. Application servers will only operate when the services are required by the client application.

5 Current Implementation

The FracSIS architecture is shown in Figure 4 with a number of application servers and possible client interfaces. Additional application servers and client interfaces are possible but are not illustrate here.

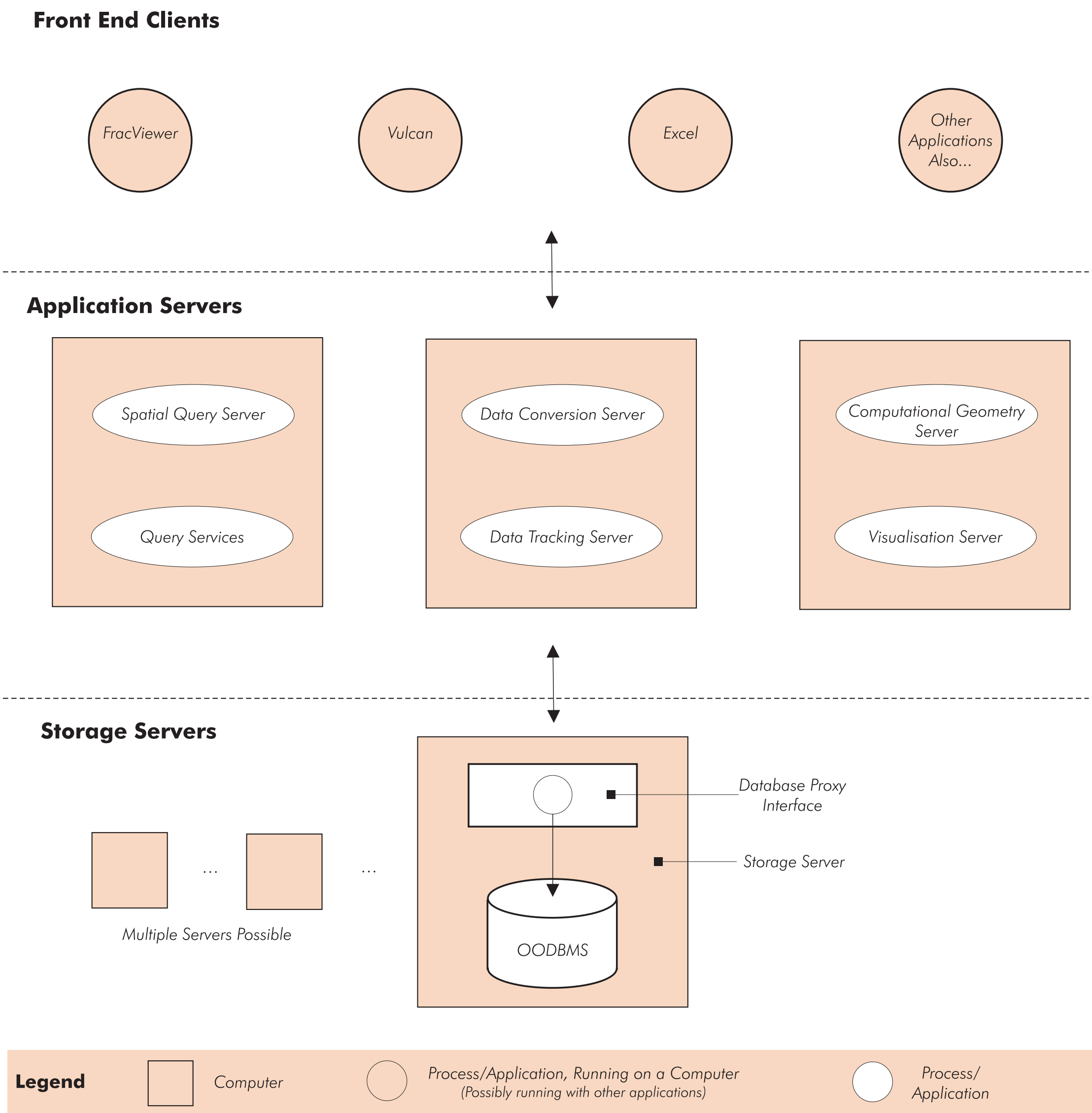

FIGURE 4. FracSIS Architecture

The FracSIS storage server

The storage server provides persistence for all data objects utilised in the FracSIS system. It may scale from a single physical system to multiple distributed systems depending on the needs of a particular site. The storage server is also responsible for transaction control, backup and low-level security requirements.

The storage server consists of two architectural components, an Object Oriented Database Management System (OODBMS) and a Proxy Interface. The OODBMS provides the physical storage and the primary functionality of the server. The Proxy Interface facilitates the inter-layer communication to the application servers.

The FracSIS application servers

FracSIS supports the use of multiple application servers that have functionality common to multiple client systems. Deployment of FracSIS does not require the use of all application servers and so a customer may choose to deploy only those servers they require. In addition, the application servers may be distributed to multiple machines and thus scale with customer needs. The diagram illustrates an example of a deployment that uses three physical machines and six application servers, two on each machine.

The six application servers illustrated provide the following services:

- **Spatial Query:** services client queries that relate to spatial parameters. For example, “find all data in the region bounded by the John Doe pit”.

- **Query:** services client queries that relate to non-spatial attributes. For example, “find all geological contacts of type 4”. The spatial query and query services can be used together to perform more complex compound queries like “find all geological contacts of type 4 in the region bounded by the John Doe pit”.

- **Data Conversion:** services client request for import and export of data that is not in the native FracSIS format. For example, a client application may be a third party system (one that does not know about FracSIS) like Vulcan. The Data Conversion service would convert the FracSIS database information to and from the Vulcan file formats so that Vulcan can read the files.

- **Data Tracking:** provides tracking of data history, derived data sources, user configurable working sets, etc. This service acts as a system for organising the data into more useable sets of information. For example, a customer may want to know what data was used to produce a particular implementation or store several versions of the same pit shell which were modelled at different points in time.

- **Computational Geometry:** services client requests for computation involving geometries. For example, a client may want to know the volume of ore in a particular model.

- **Visualisation:** services client requests for graphics representations of data. For example, a client may request that a set of drill hole logs be displayed as cylinders with rock codes displayed in particular colours.

Application servers communicate to both the client and storage server layers. Intra-application server communication is also possible. An example of intra-application server communication is the cooperation between the spatial query and query server systems when performing a complex query. To facilitate this communication Proxy interfaces are utilised on all application server components (not illustrated for clarity).

FracSIS client systems

The diagram illustrates only three client systems, (FracViewer, Vulcan, and Microsoft Excel). Additional client systems are possible (eg. FracWormer, Surpac, FracWeb) but are left out for clarity. Each client system provides support for a particular domain in the overall work-flow. In the illustration FracViewer is used for visualisation, Vulcan for modelling and Microsoft Excel for data entry. Domain specific client systems ensure that no single application need become excessively complex in the functions it performs and reduces the burden on the user. Different applications can be utilised by different personnel with in an organisation based on their needs.

The use of a unified set of application services helps ensure uniformity in data management and provides seamless linking between common aspects of the domains. This helps maintain data integrity across the domains and ensures all data relevant to a particular process are available to that user.

For example, someone performing modelling in Vulcan may want a pit shell produce by a different user in Microstation and drill hole logs produced by another user in Microsoft Excel. Since all the information has been imported into FracSIS it can all be exported into Vulcan to perform the modelling. This can then be imported back into FracSIS for visualisation of all of the data utilising FracViewer. This technique extends beyond the simple aspect of converting file information from one type to another to the semantics of the data. This means that semantic information like geological rock codes and colour assignments are maintained across the client domains. This helps smooth communication and improve data integrity.

6 Conclusions

FracSIS is intended to provide the next generation spatial information system with particular emphasis on geoscientific data sets. It will comprise an integrated suite of software modules with the core being an on object oriented database. It is designed for large (10's of gigabytes) to very large data sets (10's of terabytes). The architecture of FracSIS is predicated on an 'open-systems' approach within an integrated broad bandwidth client-server environment.

FracSIS will provide persistent storage, 3D spatial data query and data mining facilities. It will store all information within a single well-organised object oriented database. Communication of information will be via data management systems that disseminate information across networks of multiple computers running disparate software packages. FracSIS will reduce duplication and redundancy of information, at the same time providing consistency of data/visualisation representation across applications and users. The result should be significant gains in the accuracy and availability of geoscientific data to disparate operators and enable better and more informed decision making.

Database management and GIS: practical considerations and use in the exploration industry

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Abstract
Ross Mining NL has been developing rapidly, and consequently special attention has been made to developing a broad-based data management system. This task has been made easier with GIS and resource estimation software now available on personal computers. Consequently these estimations have become considerably more sophisticated. It is clear that GIS has arrived in terms of the exploration industry. Whether it is used as an intelligent drafting system or at a greater level of sophistication to derive estimates of the potential of areas to host mineralisation will depend on training and available software. There is also a need for good quality data and data management, which can become a problem with data presently available from a diverse number of sources. No matter how sophisticated the analytical software, if the data is poor, the result will be of a similar quality. This applies to all aspects of exploration from spatial mapping (GIS) to resource modeling. It is clear that data quality standards are required for GIS information if exploration companies are to fully benefit from the current trend to the use of GIS in exploration.

Introduction
Commodity prices have fallen over the last decade because of increased production through better technology and man-made substitutes. It is therefore critical that mineral deposit estimates are as accurate as possible. This process starts at the pre-discovery exploration stage and should continue through feasibility to the development stage. Different risks occur at different stages along the exploration-development path, and these are generally inter-related. More importantly, errors generated at the beginning of a project will be compounded, creating serious uncertainties at the feasibility or development stages.

Ross Mining (RSM) is presently in the unique position in Australia of bringing three mining operations into production. Recent exploration success has added significant ounces to the company's resource base at a low discovery cost of less than $6.00 per resource ounce compared to a national average of $19.00 per resource ounce (Middleton 1998). The company has been developing rapidly, and consequently special attention has been made to developing and operating a broad-based data management system.

The task of the Exploration Group is to take diverse spatial data sets at a variety of scales to produce accurate economic estimates of the mineral potential of areas of the earth's crust. Until recently this type of analysis has been carried out manually and on an ad hoc basis (Henley 1997), leading to intuitive judgements being made that had no statistical basis. With GIS and resource estimation software now available on personal computers this task can be automated and consequently these estimations have become considerably more sophisticated (eg, Bonham-Carter 1997; Singer 1995; Knox-Robinson and Robinson 1993), allowing probabilistic models to be generated.

This paper will describe some of the data acquisition, management and interpretation methods and tools currently used by RSM to assess the potential of projects either for acquisition or development. These will include:

- Databases and management tools,
- Quality control issues,

- The use of GIS to assess previous work and the scope and potential upside of a project,
- Give an example of this type of work undertaken in the central part of the Drummond Basin in Queensland.

1. Ross Mining (RSM)

RSM is recognised as one of the lowest cost producers of gold in Australia. This has, in part, been due to close scrutiny of costs at the mining stage, and also a well-defined philosophy on the style of ore body targeted. There are several factors that make a particular ore body attractive to RSM, and these form the basis of a strategy to keep the costs of production as low as possible. This philosophy is now being extended into the exploration and acquisition phase of the mining cycle.

The Company is developing mines at Timbarra in northern New South Wales and Wirralie in central Queensland (Figure 1). Production has started at the Gold Ridge Mine in the Solomon Islands and is finishing at the Yandan Mine in the Drummond Basin in Queensland (Figure 1). The mines currently in production have an equivalent total production of greater than 200,000 ounce per annum with cash costs of less than A$290 per ounce. The new projects are expected to have similar cash costs as the Yandan operation.

It is no accident that the new mines are similar to the successful Yandan operation. Several important factors were considered before a decision was made to invest in the development of the new projects. Contrary to the current trend, high gold-grades are not one of those factors. It is also clear that no single factor indicates the potential of a project, but a combination and interaction of such factors as geology, orebody geometry, strip ratio, treatment costs, recovery and mine life. These factors combine to produce a “RSM Style Orebody”.

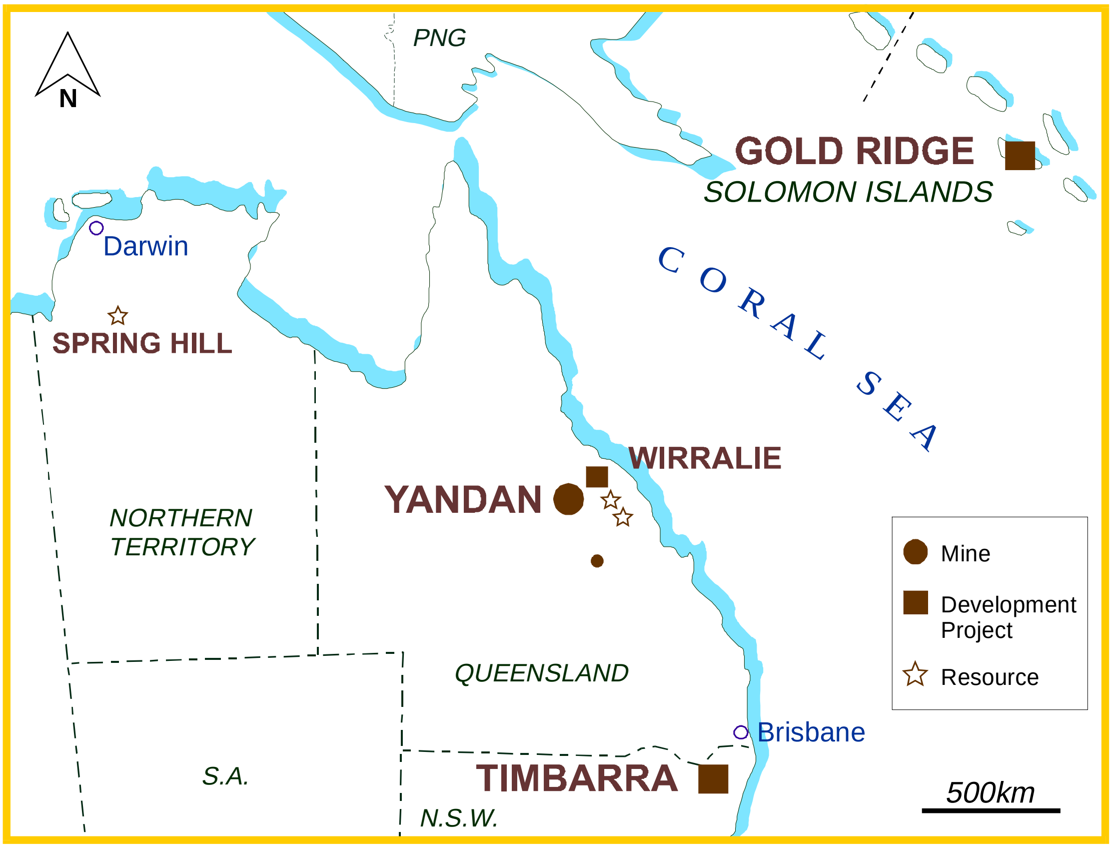

Figure 1

In the past, experience has allowed the RSM team to identify these elements within an ore body and effectively assess the risk involved in investing money to develop a project. Whilst the element of experience is still very important, new software tools and technical advances allow the process to be more objective. These tools also allow economic assessments to be made with regard to prospectivity and economic value earlier in the exploration-mining cycle.

2. Assessment at the exploration phase

RSM has built up an extensive exploration geological database over the last ten years. This represents a significant asset to the Company that has taken millions of dollars to compile. A program of digital data compilation has recently been undertaken to allow the use of more probabilistic data analysis techniques, moving away from the traditional expert-system methods. GISs are the perfect management tool for this.

A flow diagram showing the data capture and management hardware systems used by the Company is shown as Figure 2 and typical database-GIS-resource estimation software relationship are shown as Figure 3. Microsoft Access is used as the main database. The Gemcom mining package, ER Mapper and Mapinfo GIS software are all used at the exploration stage. Gemcom is used for drilling data and Mapinfo for geochemical data, geological mapping, cadastral data, and tenement data. All raster information, such as magnetic data, satellite imagery, is processed through ER Mapper. All three packages are easily linked through internal drivers saving time and errors through importing and exporting data.

Mapinfo was chosen as the GIS because of its user friendly nature and number of add-on programs

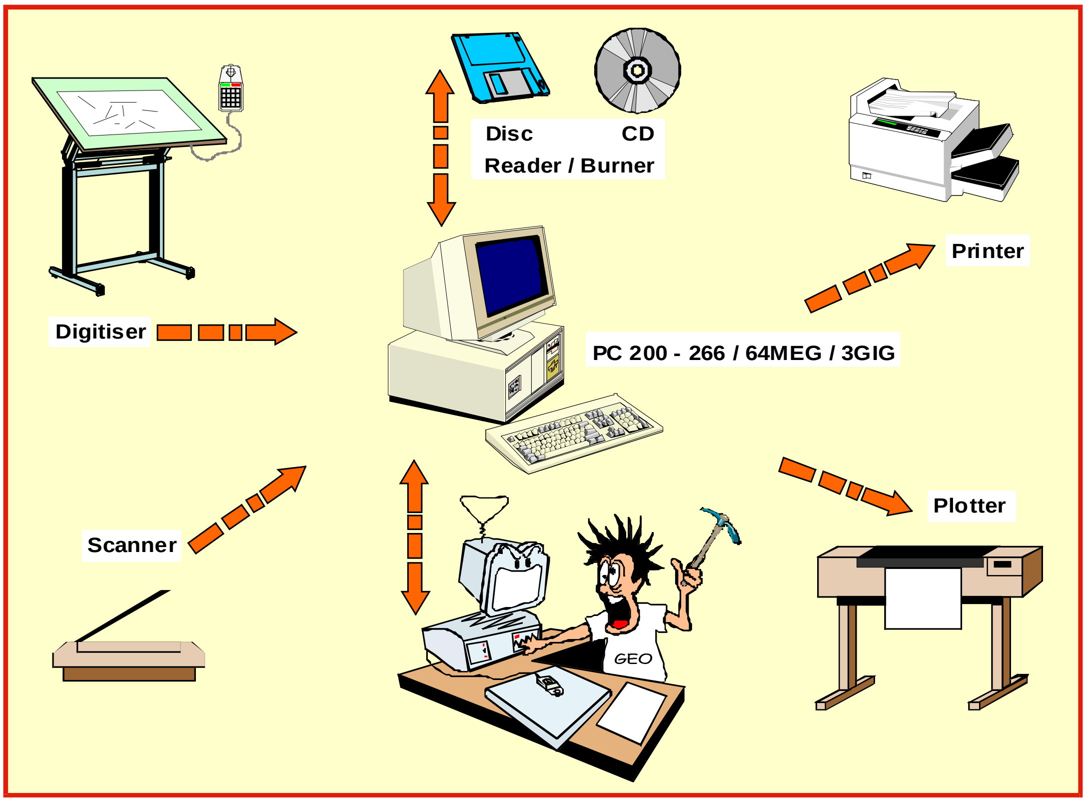

Figure 2

that turn the software from a basic mapping package into a sophisticated exploration tool. The Discover utility is used in conjunction with Mapinfo, allowing drill hole plotting, gridding and contouring, tenement management, grid conversions, map and legend production and basic statistical analysis and graphing. These tools are used to initially check the accuracy of data. In terms of data quality assessment at the exploration stage this is one of the most critical factors and with the advent of GIS systems and GPS receivers it has become clear that a proportion of older data are poorly located and not necessarily accurate. Geochemical quality control is carried out at this stage through the use of standards, blanks and repeat sampling. The results from these are then analysed statistically and plotted using scatter plots and Q-Q plots. Great care is taken with the analytical databases as these form the basis for future resource estimation, which may be subjected to external audits. The same quality issues apply to the spatial data.

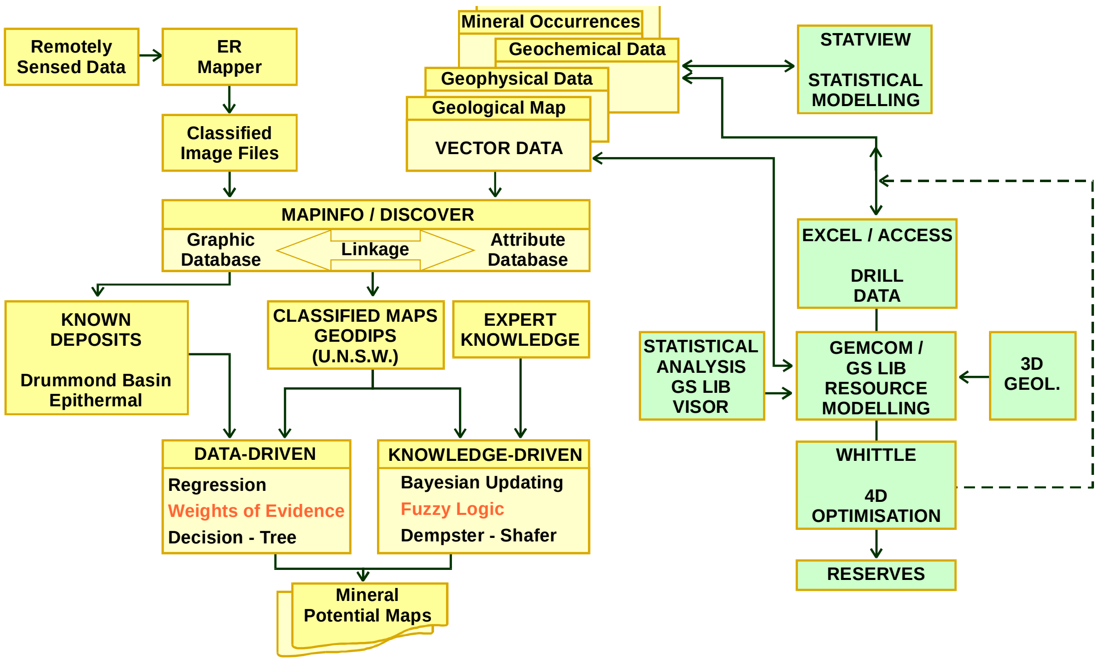

Figure 3

The GIS also allows a rapid assessment of the scope and detail of work carried out in an area. This allows for better budgeting and less repetition of work. Data compilation of this type was carried out at Timbarra, and led to the re-interpretation of previous geochemical data and the discovery of several new prospects. This work has been important in allowing new geological models to be developed while keeping the exploration expenditure to a minimum by maximising the use of the current database. Areas lacking in information were quickly defined and new exploration concentrated in these areas. The GIS was used in conjunction with GPS information to create an accurate geological map of the Timbarra Tablelands. This mapping when combined with geophysical data and satellite imagery led to a new geological model being developed, and has increased the confidence of finding additional mineralisation at Timbarra.

3. Prioritising exploration using GIS

GIS can also be used to develop more objective ways of prioritising large numbers of new exploration prospects. Prospectivity maps using weights of evidence mapping to test exploration models are useful for this type of analysis. Prospectivity mapping was completed in the central Drummond Basin around RSM's Yandan and Wirralie Projects. The work was carried out at a broad regional scale, and allowed the testing of regional exploration models. Again, the initial work involved database compilation, which highlighted errors and gaps in the database. It also highlighted the need for more detailed geological work to be carried out, and this is in progress.

Gold mineralisation in the Drummond Basin is associated with epithermal centres and appears to be lithologically and structurally controlled (Figure 3). The gold mineralisation occurs in a well-defined stratigraphic position, often associated with sinters. The mineralisation is fault controlled, and has

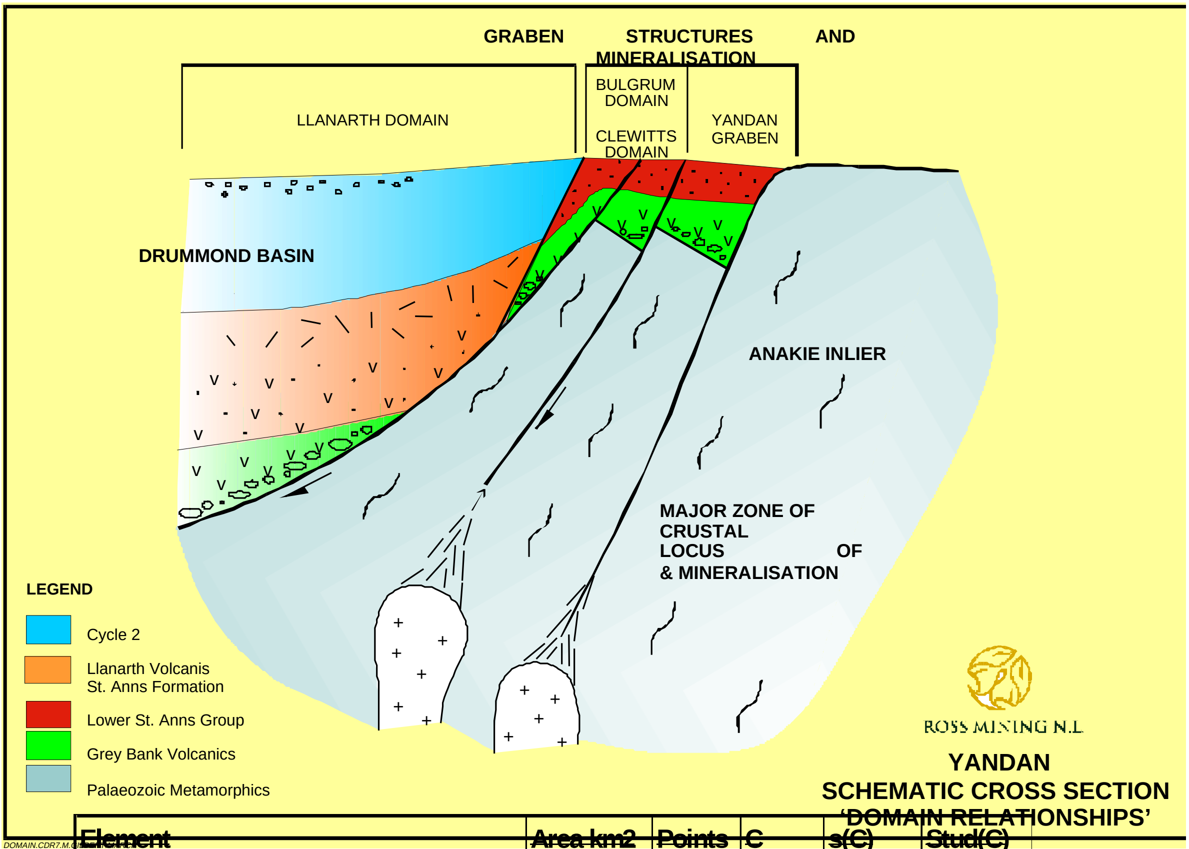

Figure 4

been found using various geochemical techniques. There appears to be two phases of mineralisation, an earlier phase related to epithermal mineralisation and a later, economically less significant, phase that overprints the epithermal gold mineralisation related to Carboniferous granite intrusion. These features form a well-defined geological model (Figure 3), which provides a set of variables to be tested by weights of evidence analysis. The variables used in this analysis are given in Table 1.

Initial work consisted of reviewing, checking data and excluding all prospects that believed to be related to the later mineralisation. Point data and vector data were then converted into raster images using numerical coding in Mapinfo (eg, Table 2). All the datasets were then imported into the University of New South Wales Geodips software package for analysis by weights of evidence and fuzzy logic techniques (Taylor 1998).

Element	**Area km2**	**Points**	**C**	**s(C)**	**Stud(C)**
Magnetic Mid Range	9176.99	68	0.171	0.3131	0.5467
Radiometrics U Mid Range	6513.48	59	0.69	0.2541	2.7134
Rock Anomalies Buffered To 400m	77.51	3	2.022	0.5886	3.4358
Rhyolite	**268.02**	**6**	**1.502**	**0.4245**	**3.5372**
Radiometrics Total Mid Range	4592.08	51	0.918	0.2326	3.9485
Radiometrics K Mid Range	**1903.98**	**30**	**1.065**	**0.231**	**4.6124**
Radiometrics Th Mid Range	5395.06	63	1.372	0.2733	5.0193
N Faults Buffered To 1700m	2431.5	32	1.246	0.2282	5.4576
Anakie Contact Buffer	2537.82	36	1.399	0.2247	6.2256
N Faults Buffered To 1800m	2668.12	38	1.439	0.2239	6.4282
E-NE Fault Intersections	753.59	20	1.843	0.2582	7.1362
NE Faults Buffered To 1100m	815.22	21	1.881	0.2541	7.205
Andesite	**49.5**	**6**	**3.206**	**0.4247**	**7.5494**
All Fault Intersections	2119.88	39	1.763	0.2237	7.8704
NE-NW Fault Intersections	318.26	15	2.373	0.2865	8.2815
Tuff	**2105.81**	**41**	**1.87**	**0.2237**	**8.3612**
All Faults Buffered To 2900m	479.09	21	2.386	0.2541	9.3883
E-NW Fault Intersections	**2272.83**	**51**	**2.296**	**0.2326**	**9.8699**
NW Faults Buffered To 1400m	**2035.16**	**50**	**2.371**	**0.231**	**10.265**
Stream Anomalies Buffered To 800m	**2267.27**	**57**	**2.642**	**0.247**	**10.6929**
Cycle 1	**1304.93**	**46**	**2.661**	**0.2262**	**11.7643**
Sinters Buffered To 2700m	**330.14**	**38**	**3.702**	**0.224**	**16.5307**

Table 1

ID	**Map Symbol**	**Cycle Code**	**Age**	**Geology**	**Geology Code**
2	Cls	5	Carboniferous	Sandstone	8
4	Dcl	3	Devonian	Tuff	7
7	Cud	2	Carboniferous	Diorite	4
3	Pug	6	Permian	Adamellite	3
17	Plp	2	Permian	Sandstone	2
1	EOc	1	Palaeozoic	Schist	1
53	Cuv	2	Carboniferous	Rholite breccia	6
122	Cubn	2	Carboniferous	Andesitic Pyroclastics	5

Table 2

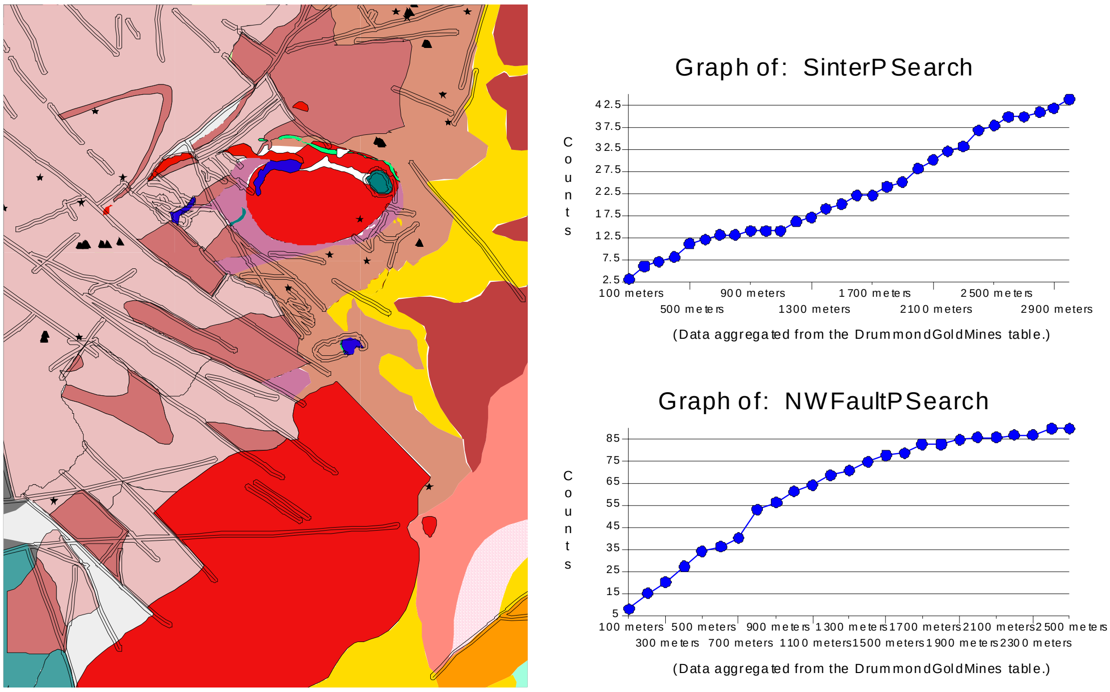

Figure 4

The raster images were converted into binary maps using geodips and buffering of various linear data including fault orientations and intersections were carried out (Figure 4). These were then

	E-NW Fault Intersections	All Faults	NW Faults + Cycle 1	Cycle 1	Acid Volcanics	NW Faults	Radiometrics K	Sinters	Anomalous Streams
E-NW Fault Intersections	***	**26.9**	**10.94**	2.94	0.13	**20.8**	**7.71**	0.03	2.46
All Faults	351056.22	***	**9.62**	**5.87**	1.21	**18.3**	0.52	0.04	1.62
NW Faults + Cycle 1	302393.59	259813.59	***	**33.01**	0.91	**40.96**	2.17	0.27	2.46
Cycle 1	56538.77	60600.24	618173.94	***	3.71	**9.94**	2.03	0.09	0.02
Acid Volcanics	8336.89	9423.22	152698.42	288981.97	***	0	1.37	**8.97**	0.02
NW Faults	442547.34	311766.34	1017875.06	78190.09	24974.44	***	1.46	0.01	**8.99**
Radiometrics K	5070.5	5710.12	23240.9	22441.58	1577.29	6964.81	***	0.92	2.18
Sinters	33851.46	27841.17	75988.53	92988.03	54124.58	57906.72	8401.13	***	0.04
Anomalous Streams	32431.04	46079.47	67395.09	55746.85	8450.53	45037.95	39451.64	51892.95	***

	NW Faults + Cycle 1	Radiometrics K	Sinters	Anomalous Streams
NW Faults + Cycle 1	***	2.17	0.27	2.46
Radiometrics K	23240.89	***	0.92	2.18
Sinters	75988.53	8401.13	***	0.04
Anomalous Streams	67395.09	39451.64	51892.95	***

Table 3

analysed to determine the prior-probability weights of evidence scores using similar techniques as Bonham Carter 1998. A table was compiled and analysed to highlight statistically the features that correlated best with the epithermal gold prospects (Table 1). The Geodips software was then used to create post-probability weights for those features that appeared to be most important in hosting mineralisation (Table 3).

A series of tests were then carried for the assumption of conditional independence (Table 3). It is clear from the current data set that this assumption cannot be met, as is the case for many geological datasets. Several variables were combined to reduce this problem and a final prospectivity map produced again using Geodips (Table 3 and Figure 5). This map was then plotted with the known prospects. This compared favourably with the known deposits, and additional prospective areas were also highlighted.

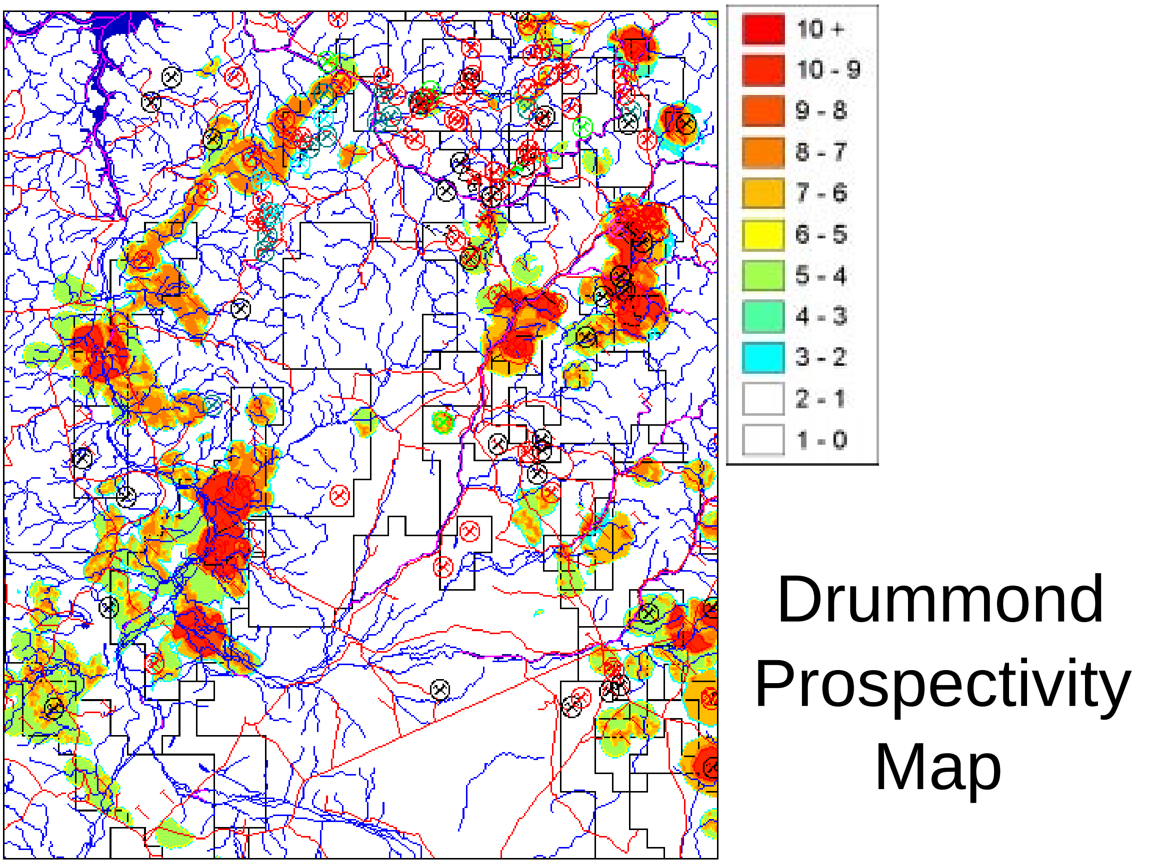

Figure 5

4. Practical considerations in the use of GIS in exploration

The end result of the Drummond Basin study, although useful, was not as important as the analysis. This provided some important lessons and provided a focus on geological models and exploration methodologies. This analysis allowed the comparison of disparate datasets and associations not easily recognisable between these datasets. The prospectivity mapping increased the confidence in the exploration models and techniques currently used in the Drummond Basin. Prioritising of prospects has been carried out leading to a better exploration focus. Risk is therefore managed at the exploration stage by ensuring exploration investment is directed to those areas held by the Company that are most likely to provide a return on that investment.

The calculation of prior probabilities produced a correlation matrix of variables comprising the geological model. This allowed an objective assessment of the model and those features that should be concentrated on during exploration. Some interesting and unexpected results were returned. It has always been assumed that fault intersections control mineralisation in the Drummond Basin and that there is some link between north westerly and north easterly structures. The weights of evidence show that faults are important, but north westerly structures are the most important. Fault intersections are less relevant. Rock chip samples give a poor correlation whereas stream sediment samples give a good correlation. This has allowed an objective assessment on the merits of various geochemical techniques. Finally sinters have the best correlation with mineralisation, confirming the basic geological model. This part of the exercise was most useful as it focused attention on database quality and the exploration models being used.

The poor results from the conditional independence tests suggest that the final prospectivity map is not accurate. However, a comparison of the post probability scores for each prospect (Table 4) has correctly ranked the size and importance of the prospects with known production. Although the result is not accurate in detail it allows a good regional ranking of an areas prospectivity. This has allowed a review of the tenement position in the area and confirmed the importance of areas to be targeted by exploration.

Prospect Name	East	North	Production Au Oz	Prospectivity
Wirralie	526920	7665240	400000	9
Yandan	497925	7642428	280000	9
Glen Eva Project	546100	7630000	85000	7
Police Creek Prospect	540000	7638500	80000	5
Mt Coolon	536600	7632700	35000	5

Table 4

5. Future directions

The data analyses at Timbarra and prospectivity mapping in the Drummond Basin have confirmed that GIS are a valuable tool in exploration. Work in the future will include improving data quality, adding to the corporate digital database, developing better methods for carrying out prospectivity analysis and developing systems to allow a smooth transition from spatial data analysis at a more regional scale to geostatistical data analysis at a resource development scale. The intention is to use these techniques to improve estimations of the metal content of areas of the earth's crust, allowing better decisions with regard to development and risk management.

It is clear that GIS has arrived in terms of the exploration industry. Whether it is used as an intelligent drafting system or at a greater level of sophistication to derive estimates of the potential of areas to host mineralisation will depend on training and available software. RSM is taking the more sophisticated route and has achieved some success in prospectivity mapping. Work is currently focussing on improving geological databases for use in prospectivity mapping.

GIS also have the potential to produce geological maps that can be best described as four-dimensional. Magnetic data was recently used at Gold Ridge in the Solomon Islands to produce a three dimensional geological interpretation of the geology around the Gold Ridge Mine. Detailed structural interpretation was then used to create a structural kinematic history for the region. The time component allows a four dimensional geological map to be produced when compiled in a GIS. Structures were highlighted that were present, and reactivated, at the time of mineralisation. A similar exercise is currently underway in the Drummond Basin. This type of analysis will greatly enhance the next generation of prospectivity maps produced by the Company

Finally, working with GIS datasets has highlighted the need for good quality data and data management. Databases are presently available from a diverse number of groups, resulting in variable data quality and standards. No matter how sophisticated the analytical software, if the data are poor the result will be of a similar quality. This applies to all aspects of the exploration industry from spatial mapping (GIS) to resource modeling. RSM is currently spending significant resources addressing this problem. It is clear that data quality standards are required for GIS information if exploration companies are to fully benefit from the current trend to the use of GIS in exploration.

6. Acknowledgments

I would like to acknowledge Ross Ming NL for their support and permission to publish company data. All members of the Ross Mining NL Exploration Group are acknowledged for their contribution to databases and ideas. The valuable assistance of Tatjana Holtz is gratefully acknowledged for the drafting of diagrams and Chris Roberts and Mike Seed for comments and helpful ideas.

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Data management—basics revisited and the implications of digital submissions by exploration companies.

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Abstract
The high cost of remote data collection more than justifies the efforts required to ensure that the quality and quantity of data collected at a location is optimised. It is equally important that the data be captured in a structured format that allows entry by non-geologists into databases tailored for GIS applications. Located point data has the potential to be incorporated in a variety of GIS projects. It is essential that the Northern Territory Geological Survey impose a certain degree of rigor for all internally generated datasets ensuring that as well as being in an appropriate type and structure, would be users also have the confidence that a dataset will meet their requirements. In addition to these internal datasets, external digital datasets, in particular tabular geochemical results, are arriving with increasing regularly as the digital reporting standards become the norm. It is of equal importance that these datasets have a level of commonality with respect to library codes, mandatory metadata, data dictionary, and structural layout. Without such standards these datasets are much more likely to remain in their original submitted format and not be merged with larger datasets for immediate on-line access.

Introduction
The Northern Territory Geological Survey is presently addressing the task of formulating improved standards for the capture of raw data by NTGS field geologists. These standards will lead to more complete datasets and be structured to facilitate data entry by data originators and/or support staff into databases. These internal datasets will, depending on data type, be merged with digital data arriving from exploration companies. Presently digitally submitted geochemical results are being loaded into NTGS geochemical database for on-line access. An encumbrance to this loading is the diversity of formats, structures, library codes and data dictionaries from submitting exploration companies. This problem has been identified for a numbers of years, and is the focus of the AMIRA P431 geoscience model initiative. This focus will remain with increased intensity, as digital reporting becomes the norm. To alleviate this problem state and territories agencies must introduce a level of rigor that goes beyond requesting digital data on a particular media and format and extend to the more specific i.e. library codes, data dictionary terms, and mandatory metadata elements.

Some IT background
Corporately the Northern Territory Department of Mines & Energy have moved from a Unix to a Windows95/NT platform and from Sybase to an Oracle/Spatialware database system. The Oracle/Spatialware data management system is presently serving the needs of our soon to be released Titles Management System, however, it is anticipated that NTGS will adopt the functionality of a spatial database engine as datasets become more complex and effectively break the shackles of individual projects.

Although the NTGS has collaborated on GIS packages with AGSO previously, NTGS can still be considered a Johnny-come-later when people mention GIS functionality. NTGS is presently addressing this image from the bottom up by strengthening its data capture procedures and database arsenal. To this end NTGS has acquired Explorer3 from Terrasearch, Ozrox field collection database from AGSO, and has recently revamped its Mineral Occurrence Database (NTMOD). All these databases are in Microsoft Access or Visual Basic. To effectively populate these databases NTGS will require a level of structure to all future field data capture procedures. Though getting the right data stored in a suitable structure for GIS application isn't as exciting as the actual analysis and interpretation of the data, it is no less importance. Only when this platform is established can NTGS effectively launch into what will be a project based GIS implementation. MapInfo is NTGS desktop application of choice. This project approach will deliver, in addition to the conventional print on demand geological maps and reports, stand-alone GIS products.

Internal datasets—collection

Internal restructuring of data management: Codes–Data Dictionary–Structure–Metadata.

Optimizing field data collection by:

- Employing structured hardcopy notepads for field observations (Ozrox)
- Use of attribute forms for all samples collected in the field i.e. rock chips, soil samples.
- Use of forms to capture all attribute information associated with mineralisation.

Sending geologists into the field is a costly affair. Locations visited are usually never revisited, so it is imperative that the collection of observational data is optimised. To achieve this end, structured notepads will be re-introduced into NTGS for the up coming field season. The Ozrox notepads (hardcopy) will be utilised, and amended to meet NTGS specifications. These amendments, if any, won't impact on field data transferred to AGSO's national field observation database. In addition to these notepads field geologist will utilise a sample form. This form will only take a few moments to complete, and one must be completed for each sample taken in the field. This form has been modelled on the format within Explorer3 field data collection kit. All mineralisation from mineral occurrence to mine data will be noted in the NTMOD mineral occurrence form. The MODAT form will generally be utilised by geologists (re)visiting mine sites. The use of structured notepads and forms will act as a prompt so that data isn't overlooked after prolonged periods in the field.

There has been some opposition to this structured from NTGS geologists, stating that field collection methods should remain within the individual domain, and that a structured approach with its myriad of codes may inhibit their ability to capture data. Field tests by some of our NTGS geologists during the late eighties to early nineties doesn't support this argument. The opposite can be said, with all who used a structured approach stating that their initial fears were dispelled as data quality and quantity were improved. In addition most geologists learnt the necessary codes for a particular area within 50 entries.

Internal datasets—data input

By imposing a data collection structure in the field, NTGS can then reap the benefits during data input.

Methods of data input:

- Templates for large repetitive format datasets e.g. geochemical datasets in tabular format.
  - Support staff will be responsible for data entry.
- Manual entry for non-repetitive format e.g. field observations/mineral occurrences.
  - Mixture of support staff and data originators.

Bulk loading of repetitive datasets (Explorer3 - NTGS preferred geochemical database)

A geoscience technician will be responsible for merging assay digital data from the laboratory with the sample attributes noted on the hardcopy sample forms. Once merged these data templates will be dumped to the corporate geochemical database.

Manual Entry of non-tabular datasets (Ozrox)

All field observation data will be loaded into this database by the data originators either in the field or back in the office.

The validation rules and look-up tables inherent in this database will exclude the most obvious errors, while a quarterly check up by the database custodian will deal more with the intellectual content.

Small, Dynamic non tabular datasets (MODAT - Mineral Occurrence Database)
The Mineral Occurrence Database will also require the data originator to be person who inputs the data. The Mineral deposit database is small and dynamic, so it lends itself to this level of intimacy. As with Explorer 3 and Ozrox lookup tables and validation will prevent obvious entry errors. The intellectual validation will occur quarterly by the database custodian.

A summary of the transition from Sybase to Access 97—Mineral Occurrence database

For a long time NTGS could really only call one geoscience database truly its own, the mineral deposit database or Mindeps as it was known. This database, designed in-house, was a Sybase application and contained all the known mineral occurrences in the Northern Territory. In 1998, as part of major database initiative, NTGS decided to migrate the Sybase version to Access97 with an emphasis on making the database compatible with GIS applications. At the initial design stage mature interstate mineral databases were reviewed. To ensure the new database would be used as a primary source for GIS applications, long textual strings and comma delimited fields weren't allowed. Field sizes were restricted as much as possible, with the free text comment field designated the only exception.

Future coordinates will be entered as full AMGs or MGAs, with the associated zone, location method and accuracy. Previously the coordinates were entered as apha-numeric UGRs e.g. MU345678 with metadata elements such as locational accuracy and accuracy method absent. The new database will disregard the assertion that computers can handle code better than full term, and restrict coding to a minimum. The resource geologists or mapping geologists will use code or abbreviations in the field for speed, however, only full terms will enter into the database.

The Database has a two core tables, the Tbl_Site and Tbl_General_ Data tables. The site table is generic, and will be used for all future NTGS point data for future in-house developed databases. The general data table is specific to the Mineral Occurrence Database, along with a further 21 data tables that include, among others, commodity, host rocks, metamorphism, lithology, production and resource details. Associated with the data tables are 47 look-up or library tables. These library tables will be amended as required by consensus from the resource geologists and database custodian. The new database also includes completely new data fields that will require retrospective population by the data originators. All field names and domains, where possible, conform to the data dictionary specified by the AMIRA P431 initiative.

Data migration from the Sybase version to the new Access version proved difficult and time consuming as the new database was intentionally very structured, possessing many validation rules and look-up tables. As previously stated, the long textual strings required deconstructing into concise searchable terms prior to migration. This editing was done by the original data collectors in order to maintain data integrity.

The primary purpose for this new database is to allow NTGS to deliver concise datasets to GIS applications so that spatial analysis and modelling can occur in association with other datasets.

Corporately, the database will be split, with the data tables accessed from a network server. It is envisaged that the back-end data tables will be migrated over to the corporate Oracle database platform in the near future.

Presently the new mineral deposit database is under going in-house trails, and should be released to the public on CD-ROM in July 1999 with documentation. Presently the database has 2784 mineral occurrences (and growing), including both metallogenic, industrial and construction commodities.

External datasets—digital assay data submitted by exploration companies

Data Entry – Company-generated point datasets - specifically geochemical assays from drilling, soil sampling & rock chips.

Custodial Responsibilities once data is submitted to department;

- **Ensure submitted data is complete and accurate.**

Quality check by Titles Geologists

- **Keep the data safe.**

Original data submitted on short-term storage media (i.e. floppies) will be stored on long term storage media - (i.e. from floppies to CD-R or DLT tapes?)

- **Make the data accessible**

Thorough and accurate indexing of original digital data submissions allow efficient search and retrieval.

- **On-line access of merged datasets.**

NTGS is currently importing all geochemical datasets received form company reporting into the Explorer3 database. The difficulty of this process has been alleviated to a certain degree by utilising the templates specific to Explorer3. The preparation of these templates would be further hasten if standard formats, codes, metadata, and data dictionary terms were utilized in the submission of this data.

Removing the surprises from digital assay submissions.

The promotion of digital reporting throughout the states & territories has firmly put the spotlight back on the AMIRA P431 initiative. This initiative produced a geoscience data model based on a modular approach to the way data is structured i.e. Site information is common whether it refers to geochemical, geological or any other data type. AGSO has followed this approach for a number of years and NTGS has also embraced this concept in the design of the new Mineral Occurrence Database with the site table be generic rather than specific to mineral occurrences. The recent GGIPAC (Feb' 1999) has again endorsed the importance of this initiative by agreeing that the data dictionary from AMIRA P431 should be actively promoted, and if codes are to be used, than the emerging AGSO national standard should also be promoted.

In the Northern Territory, as with the states, digital reporting isn't mandatory yet, with companies being asked to submit both digital and hardcopy reports over the transition period (1 January 1999 to 31 December 2000 for NTDME). The vast majority exploration companies have embraced this initiative, which could be said to have originated from their frustrations in submitting reams of hardcopy printouts, in particular assay data.

NTDME is now receiving more digital datasets as prescribed by our digital reporting standards. A very visual expression of these submissions has been the geochemical assay results that usually are submitted in a tabular format. The digital submissions of assay data is not new, as most companies have included a data floppy within their hardcopy report for a number of years. These digital datasets will be transferred to a long-term storage media, and indexed for quick search and retrieval. An additional step, and a logical consequence of digital submissions, is the provision of on-line access to these datasets. NTDME is presently loading these datasets into the Explorer3 database. Bulk dumps using Explorer3 templates have made this job relatively straightforward; however, the myriad of company specific tabular data structures and geological codes have made the job a challenge even for the most astute geological operator. A common tabular structure, data dictionary and coding system would certainly expedite the process. Such data standards and structure could at the very least be used as a transfer mechanism between state bodies and exploration companies. Agencies receiving a known, common format & structure would be better placed to manage these datasets. This idea is not ground breaking, and could be considered in line with the relational geoscience model advocated by the AMIRA P431 initiative, and the more recent GGIPAC recommendation regarding the submission of tabular digital data.

Summary

NTGS is establishing procedures for the collection of field data. These procedures rely on a structured approach for what could be considered mandatory field data. This approach in no way diminishes the individual's right to expand on these mandatory data requirements.

NTGS is expanding its geoscience database arsenal. For many years NTGS has had only one geoscience database it could call its own - Mindeps (Mineral Deposit Database). This database has now been moved from Sybase to Access97 (MODAT) with an emphasis on GIS compatibility Other geoscience databases include Explorer3 and Ozrox. NTGS's philosophy is one of not trying to re-invent the wheel with regard to geoscience databases i.e. if other suitable geoscience databases exist elsewhere than these should be acquired or purchased in preference to database development.

The submission of geochemical digital data from exploration companies will be loaded for on-line access. The ability to load these disparate datasets is presently hampered by the myriad of library codes, inconsistent use of metadata elements, variations in data dictionaries and structural layouts. The inconsistency of digital datasets from companies could be alleviated to some degree by the promotion of the AMIRA P431 data dictionary, and AGSO codes. Such a promotion has already been encouraged by state & territories government agencies at the recent GGIPAC meeting.

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The COGENT mapping and production system

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Introduction

The new COGENT mapping methodology is aimed at accelerating the rate of regional geological map production and increasing the rate and range of information that is available to clients. Prototype mapping projects are currently being carried out for the Cargelligo and Goulburn 1:250,000 sheets.

Features of the new model include:

- Emphasis on corporate digital data
- Generation of interim products - maps, CD's, GIS applications
- Stronger teamwork - use of fieldcamps, geologists/cartographers
- Shorter work cycles.
- New structured field data collection procedures
- Early data capture - integration of digital geology, remote sense data and site data at an early stage.
- Improved use of information technology
- Emphasis on fact/outcrop mapping.
- Descriptive unit notes compiled following completion of each fieldcamp.
- Cartographic role of data management - metadata, standards etc.

1. Emphasis on corporate digital data

The major change in the new mapping procedures centres around the need to treat the regional mapping program as a data capture exercise where the main outcome is the creation of a corporate database of spatial and attribute data. The emphasis therefore changes from digital map data to digital corporate data from which a variety of applications and products can be derived.

2. Products

From this corporate data, products at various stages of the process can be made available in both digital and hardcopy form. This will include, but not be limited to; data for the production of cartographic quality maps, data suitable for GIS applications and analysis, and data for distribution to industry to promote exploration.

The COGENT mapping process has defined three distinct definitions of products.

- *Interim Output* - work in progress, although project incomplete, data now made available to internal and external clients
- *Provisional Product* - early release of completed product for use by external clients, documented quality control.
- *Publication* - any product which has been through editorial review.

Note : The six 1:100,000 maps and the 1:250,000 map will be taken to "publication" stage, however only the 1:250,000 map will be printed (in four (process) colour). The 1:100,000 maps, as well as the interim and provisional products, will be supplied as "on-demand" plots.

3. Project teams

A key element in the new mapping procedures is the development of stronger mapping teams, working together in fieldcamps and including all team members; geologists, geophysicists, cartographers and support staff from the commencement of the project. The mapping team will focus on 1 X 100 000 sheet at a time. Mapping areas for individual geologists may be assigned on a thematic or areal basis.

Field mapping is undertaken with all team members in the field together operating from a base camp. Ideally the field camp is located (and relocated as necessary) central to the mapping area. Availability of suitable camps may influence the planning strategy but locating all team members together in the field is a vital element of the new procedures.

4. Shorter work cycles

Figure 1 shows a representation of the new 1:100,000 mapping model commencing with the fieldwork. The cycle time shown in this model is six weeks, which at this time is an estimate only but does emphasise the important concept of compiling and checking geology and point source data following each field trip. By working in short cycles, the work of each field trip is finalised, captured in digital form and stored as corporate data.

5. Structured field data collection

During the pilot implementation, field observations will be recorded in structured field notebooks using dictionaries of approved terms. Data from the notebooks is entered into the Access outcrops database preferably in the field or immediately following the completion of each fieldcamp. Palmtop computers for onsite field data collection will be trialled during the course of the pilot program following completion of the trial of the new Access database and the structured notebooks.

The benefits of the new structured field data collection procedures are improved accuracy, consistency and timeliness of data.

6. Improved mapping process

- **Geophysical interpretation workshop**

At the beginning of the project a geophysical interpretation workshop is undertaken by team members over 3 or 4 days to produce detailed basement interpretations for each of the six 1:100 000 sheets comprising the project area.

The geophysical interpretation is a critical element of the planning process and is used to identify and target the major geological issues to be resolved by the mapping. The interpretation also comprises a major product that can be made available to clients at an early stage of the project as hard copy or as a layer in the first edition GIS.

- **1:50,000 scale fact/outcrop mapping :**

The field mapping process is directed toward producing an outcrop or fact map. In areas where this is not feasible, the field component of the mapping process should be as least interpretative as possible

- **Early data capture**

Following the completion of each fieldcamp, the geological line and polygon data generated is compiled onto stable plastic bases at 1:50 000 scale for scanning by the Cartographic member of the team.

This process generates a compilation for the results of each field camp which after scanning are to be passed back to the mapping team for checking against geophysical data in ArcView. Point data collected by each field geologist is plotted by them against the polygon and line data in ArcView and verified for positional accuracy.

The cycle of fieldwork, followed by compilation, scanning and checking of polygon, line and point data in ArcView will result in a completed compilation at 1:50 000 scale which has been substantially checked and verified by the mapping team.

Each completed 1:50 000 compilation is then vectorised and attributed by cartography to publication standard. The completed vectorised layer is then passed back to the project leader for checking and editing as required prior to release as a preliminary mapping product.

Outputs

◊ Progressive compilations of fact/outcrop geological line and polygon data onto stable plastic at 1:50 000 scale.
◊ Scanned images of geological compilations for checking in ArcView.
◊ Preliminary geological line, polygon and point data available to clients.
◊ 1:50 000 scale vectorised compilations with references (generated from Oracle)

- **1:100,000 scale map compilation**

The standard 1:100 000 scale map area is then completed by cartography for the fact/outcrop layer by joining two completed and vectorised 1:50 000 component map areas. The map is completed with surrounds, an auto generated reference and cross-sections.

Following completion of the 1:100 000 fact/outcrop map, this data is workshoped by the team to produce a solid geology interpretation layer.
This layer Is to be completed by cartography with surrounds modified from the fact/outcrop layer.

Outputs

◊ 1: 100 000 fact/outcrop compilation with surrounds (references and cross-sections etc).
◊ 1: 100 000 solid geology interpretation with surrounds (references and cross-sections etc).

7. Descriptive notes

A compilation of descriptive notes for each unit mapped is compiled by each geologist for their mapping area immediately following each fieldcamp. The team geophysicist is responsible for compiling petrophysical descriptions for each unit in the map area.
This should substantially reduce the formal note writing task and provides another product available to clients at an early stage.

8. Cartographic role of data management

The role of the cartographer has been extended from pure map production to managers of corporate digital spatial data. The Cartography Unit has developed expertise in the capture and display of digital spatial data within the GIS and the data modelling issues that arise from the use of the GIS. It is because of this expertise and their role of data managers that the Cartography Unit has been identified as data custodian for corporate spatial data, related to regional mapping.

A corporate data model has been developed for spatial data including a fully relational data structure for spatial and attribute data.
A standard Look-Up table of feature codes for the Geological Survey ArcInfo GIS, with a newly devised numbering system, has been developed, which extends and enhances the AGSO LU table, meeting the Department’s specific requirements while maintaining a high degree of compatability with AGSO.

9. Data model.

The data captured by the cartographer is loaded into the corporate data repository which is managed within the Spatial Data Engine (SDE). Coverages are on AMG; SDE is in Lat/Long, both using AGD66

SDE runs in ORACLE on a DEC server running OSF/1.

The SDE data model consists of a series of geological themes, each with a set of working and archive layer.

a) Working data represents the current data on the custodian’s workstation with uploads of new data replacing existing data in the SDE layers

b) Archive data represents a history of data for all layers and custodians will archive their data at key points in the development process.

Summary

Although still being developed within a pilot project, the new geological mapping process for N.S.W Department of Mineral Resources promises many benefits over traditional methods. The shorter work cycles, closer project teams of geologists, cartographers and specialists, and emphasis on corporate digital data will mean that the Department is better able to service it’s clients with a wider range of products at a much earlier stage.

References

Watkins J.J., 1999.“Cogent model for the business process of regional geological mapping”

Geographic Business Systems Pty. Ltd. “Workflow business change analysis for geological mapping”

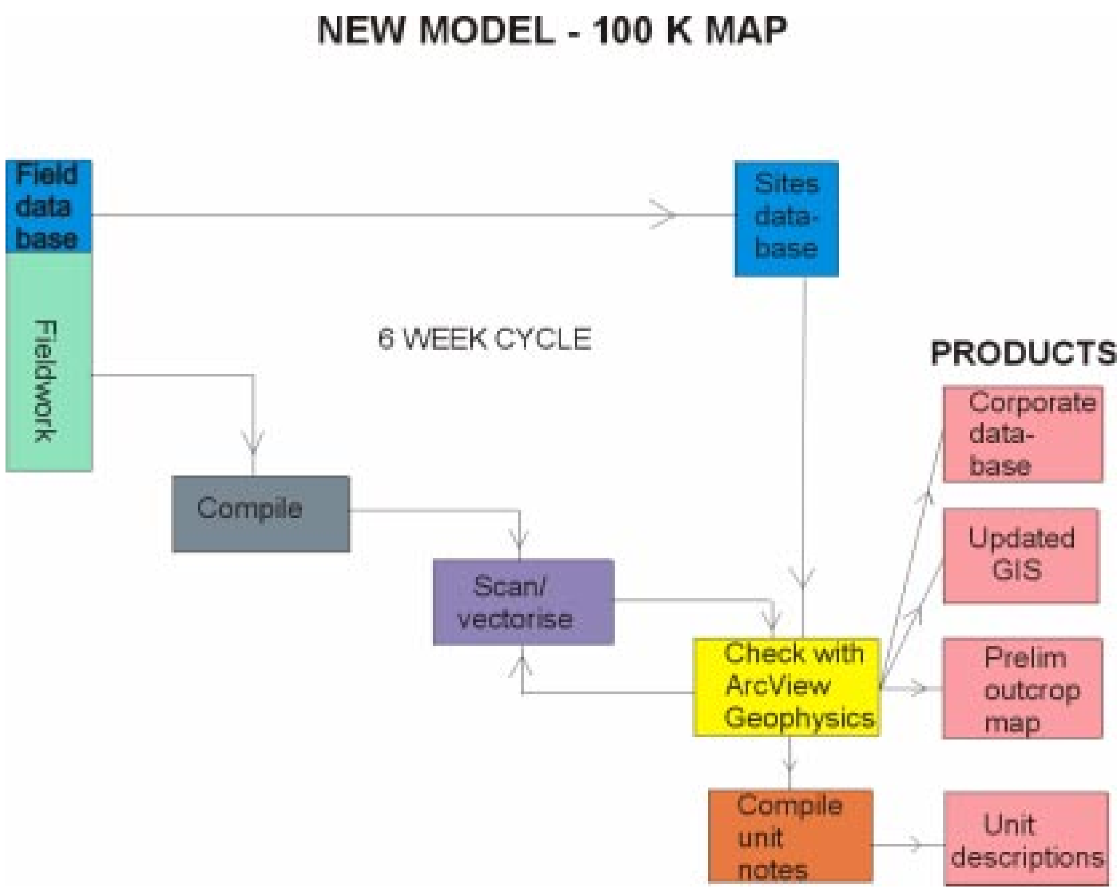
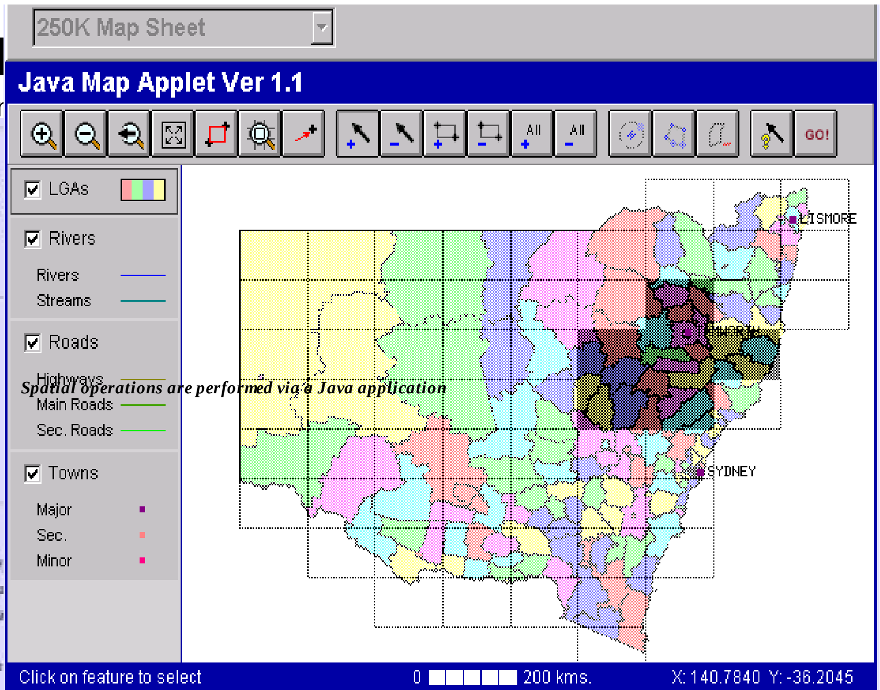


Figure 1

What is COGENT…

The Geological Survey of NSW is a bran

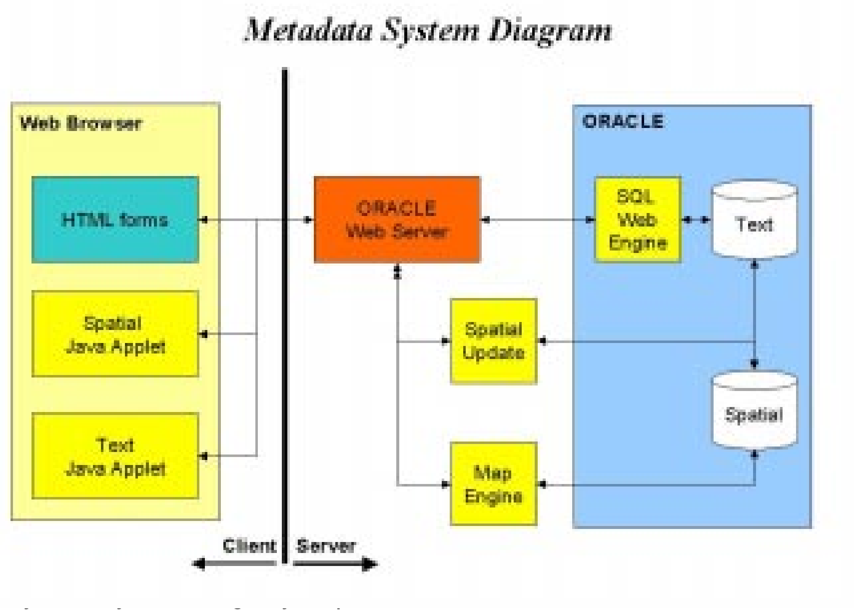


ows users to enter text and spatial

et the search parameters. Users can then choose to examine individual Projects that are part of the Corporate Activities. Summary information and full reports are provided for each Corporate Activity and Project.

Metadata Update System:

This is password controlled and is only available to Data Custodians. It allows new Projects to be created or the metadata for existing projects to be edited.



Benefits …

The aim of the COGENT project is to increase particular within the Geological Survey.

By increasing access to data it is intended Regional Mapping, Landuse Enquiries and a The Metadata Enquiry System will allow users searches. The text search will search specific fiel By being able to easily determine what data is especially affect the turn around time for client q Industry will benefit by having better access to th

Who will use it…

The system is intended to be used by ge Department. However, a wide range of p determine what data is available for a specifi

The current system is available on the Depa public or industry representatives can use th

A future expansion to the Internet is being considered. This will greatly facilitate access to the general public and to industry.

Major components…

HTML Forms:
Active HTML pages with embedded forms are used for all text search activities.
Results are returned as formatted HTML reports. An option also exists to export as ANZLIC export format.

Spatial Java Applet:
This allows the user to interactively specify an area of interest to spatially limit the text search.
Data custodians can also graphically enter the spatial extent of new data sets.

Text Java Applet:
Allows data custodians to update the text metadata in ORACLE.

SQL Web engine:
PL/SQL code that performs the bulk of operations within the system. Routines generate the HTML pages, query the database and control access to the update system.

Map Engine:
Retrieves spatial and attribute data from the SDE databases and displays it on the Spatial Java Applet. It is written in C.

Spatial Update:
Automatically updates the spatial extent polygons associated with the metadata after custodians make changes. It is written in C.

Technology…

The COGENT Metadata system is implemented as an Intranet solution on the Departments Wide Area Network (WAN).

The Department operates a Digital 8200 server running the OSF/1 operating system.
The metadata resides in an ORACLE 7 database and related spatial data resides in the Spatial Database Engine Version 3.0 (SDE) from ESRI. SDE allows spatial data to be stored within an ORACLE database.
Web serving is performed with the Apache Web Server. This is the Departments preferred web server. Other web servers can be supported.
Programming was performed using PL/SQL, Java, C, and Perl.
Java programming used the Symantec development tools.
Database design and data modeling was performed using ORACLE Designer 2000 tools.
The application assumes that a browser equivalent to Netscape 4 or higher is being used. This is principally to cater for the use of Java applets.

Contacts…

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Geographic Business Systems:
Mr Scott McDonell (02) 9241 2138

Metadata System

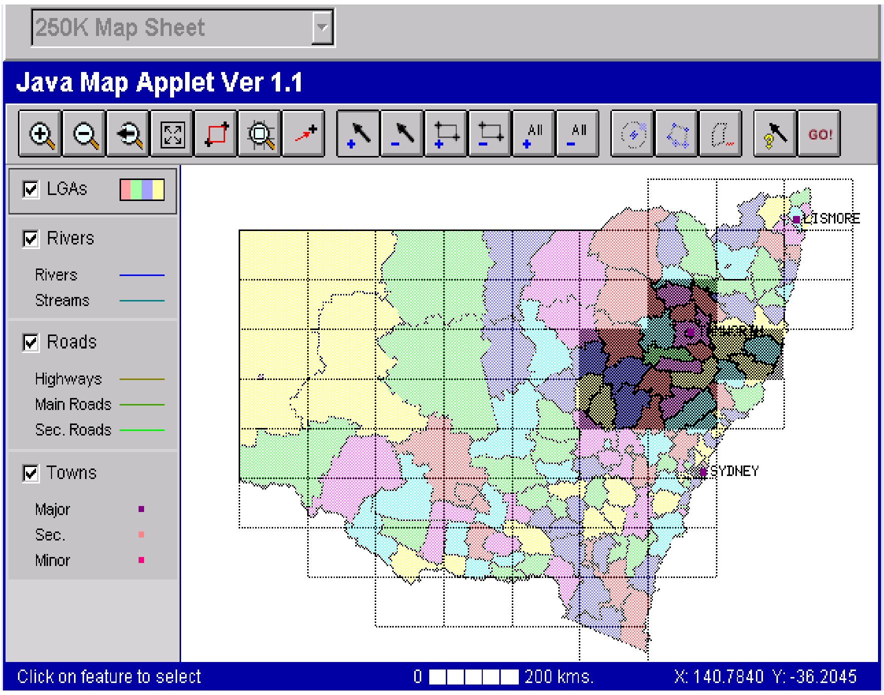
COGENT White Paper No. 1 **June 1998**

What is COGENT…

The Geological Survey of NSW is a branch of the NSW Department of Mineral Resources. In 1997 the Department awarded a contract to Geographic Business Systems Pty Ltd to develop a Common Geoscientific Environment (COGENT).

The project started in August 1997 and is due to be complete in January 1999.

This document discusses Activity One, the development of a Metadata System. The Metadata System was completed in May 1998.



Spatial operations are performed via a Java application

What is metadata…

As the department has developed databases over the past decade there has come a realisation that unless it is possible to associate secondary information with the primary data then the usefulness of that primary data is severely limited.

This secondary data holds information such as the spatial accuracy of the primary data, who captured it and when and the original use of the primary data. This secondary data is known as metadata.

The Australian and New Zealand Land Information Council (ANZLIC) has established guidelines for metadata which describes spatial data. The Departments metadata fully supports the ANZLIC guidelines but includes extensions to meet the Departments business needs.

Currency and Status

Beginning Date :	Not Known	Progress :	Not Known
Ending Date :	Not Known	Maintenance and Update Frequency :	
Metadata Date :	06-APR-98		
Current Version :	1		

Access

Available Format Types :
NON DIGITAL MapInfo
NON DIGITAL ArcView

Confidential? : N

Access Constraints :

Data Quality

Lineage :	Mostly derived from Departmental source
Positional Accuracy :	Varies according to dataset 50 to 500 metres
Attribute Accuracy :	Most checked during data compilation
Logical Consistency :	You bet!
Completeness :	Data from existing datasets and compiled from GS reports back to 1970

Extract from a full metadata report

System Description…

Metadata Enquiry System:
This is accessible by anyone with access to the Departments WAN. It allows users to enter text and spatial search parameters and returns a report on the Corporate Activities that meet the search parameters. Users can then choose to examine individual Projects that are part of the Corporate Activities. Summary information and full reports are provided for each Corporate Activity and Project.

Metadata Update System:
This is password controlled and is only available to Data Custodians. It allows new Projects to be created or the metadata for existing projects to be edited.

Benefits …

The aim of the COGENT project is to increase access to geoscientific databases held throughout the department and in particular within the Geological Survey.

By increasing access to data it is intended to facilitate the business of the Geological Survey which includes; Regional Mapping, Landuse Enquiries and answering client queries, in particular from the Exploration Industry.

The Metadata Enquiry System will allow users to determine the availability of data by using text searches and spatial searches. The text search will search specific fields, use key words, or search the whole database.

By being able to easily determine what data is available, the Departments business activities will be improved. This will especially affect the turn around time for client queries.

Industry will benefit by having better access to the Departments data, thus facilitating exploration in NSW.

Who will use it…

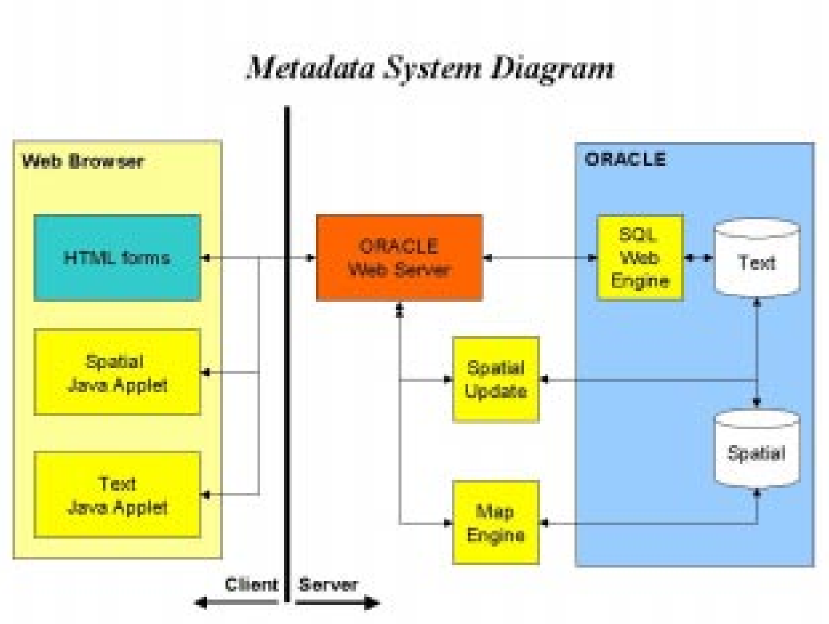
The system is intended to be used by geologists, geophysicists, cartographers and other personnel of the Department. However, a wide range of people will benefit from the ability to clearly and unambiguously determine what data is available for a specific spatial area or for a specific topic.

The current system is available on the Departments intranet and is designed for inhouse work. Members of the public or industry representatives can use the system by attending any Departmental office.

A future expansion to the Internet is being considered. This will greatly facilitate access to the general public and to industry.

Major components…

HTML Forms:
Active HTML pages with embedded forms are used for all text search activities.



Results are returned as formatted HTML reports. An option also exists to export as ANZLIC export format.

Spatial Java Applet:
This allows the user to interactively specify an area of interest to spatially limit the text search.

Data custodians can also graphically enter the spatial extent of new data sets.

Text Java Applet:
Allows data custodians to update the text metadata in ORACLE.

SQL Web engine:
PL/SQL code that performs the bulk of operations within the system. Routines generate the HTML pages, query the database and control access to the update system.

Map Engine:
Retrieves spatial and attribute data from the SDE databases and displays it on the Spatial Java Applet. It is written in C.

Spatial Update:
Automatically updates the spatial extent polygons associated with the metadata after custodians make changes. It is written in C.

Technology…

The COGENT Metadata system is implemented as an Intranet solution on the Departments Wide Area Network (WAN).

The Department operates a Digital 8200 server running the OSF/1 operating system.

The metadata resides in an ORACLE 7 database and related spatial data resides in the Spatial Database Engine Version 3.0 (SDE) from ESRI. SDE allows spatial data to be stored within an ORACLE database.

Web serving is performed with the Apache Web Server. This is the Departments preferred web server. Other web servers can be supported.

Programming was performed using PL/SQL, Java, C, and Perl.

Java programming used the Symantec development tools.

Database design and data modeling was performed using ORACLE Designer 2000 tools.

The application assumes that a browser equivalent to Netscape 4 or higher is being used. This is principally to cater for the use of Java applets.

Contacts…

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COGENT Database

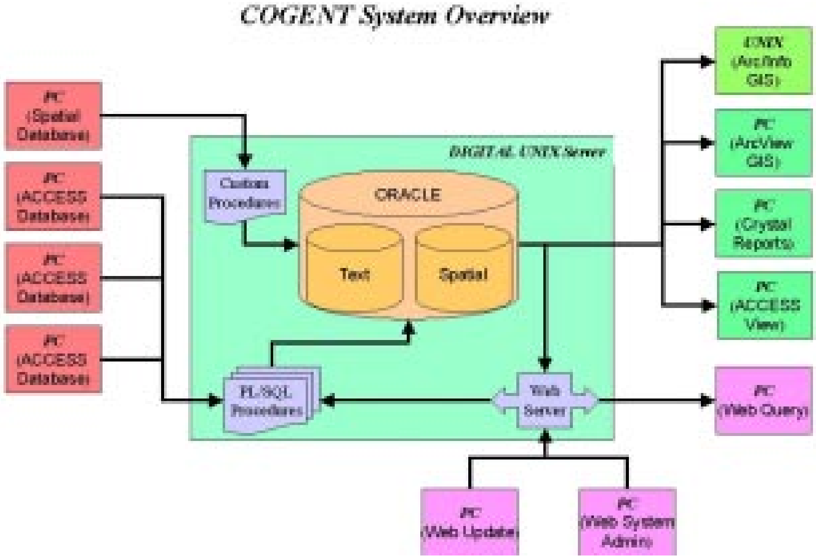
COGENT White Paper No. 2 — **March 1999**

What is COGENT…

The Geological Survey of NSW is a Division of the NSW Department of Mineral Resources. In 1997 the Department awarded a contract to Geographic Business Systems Pty Ltd (GBS) to develop a corporate geoscientific data repository with associated data view and loading applications. This is COGENT - the Common Geoscientific Environment.

The project started in August 1997 and was completed on time and on budget in February 1999.

COGENT System Overview



Aim…

- Develop a common data repository for all corporate geoscientific data.
- Provide software tools that will allow easy access to the data repository by all personnel, thus improving communication, co-operation and efficiency within the Department.
- Providing a foundation for future deployment of data via the Internet.

Data Sources…

As with many organisations, the Department has a plethora of specialised applications and stand alone databases. These have been developed by individual custodians with the aim of meeting their immediate needs for data management, analysis and display.

The Department manages two distinct types of data; **Spatial** (map-based data) and **Attribute** (descriptive data).

Most of the **attribute** datasets are managed within Microsoft ACCESS. Others exist in legacy mainframe systems while some units within the Department had no structured manner for managing their data.

Most of the **spatial** data is held in ESRI or ER Mapper formats.

Data Repository…

In line with the Departments Information Systems Strategy, all data is to be held in ORACLE RDBMS with ESRI's Spatial Database Engine (SDE) being used to hold and manage spatial data, also within ORACLE.

The COGENT data model is partitioned into individual modules, where each module represents the data model for a particular dataset. Wherever subsets of the data resemble data in other modules common field names have been used. This is particularly the case with locational data, where common attributes are used to describe where the data was collected.

Where an ORACLE dataset is derived from an ACCESS dataset, the ORACLE data model resembles that used in ACCESS but does not duplicate it.

Lookup tables (tables that contain descriptive information for database codes) are either unique to a single module or shared across multiple modules.

Ongoing consultation between dataset custodians will occur to determine mutually acceptable values for shared lookup tables.

Data Access…

General Access:
Non-confidential data is made available on the Department's intranet so that anyone with a standard web browser is able to view it. Initially a basic set of functionality has been provided, but this may be expanded in time.

Specialist Access:
Users with skills in using third-party products to access data (eg, ArcView or Crystal Reports) have access to non-confidential data tables in order to perform ad-hoc queries and analysis. Custodians can also view confidential data.

Specialist intranet applications such as Boreholes, Seismic Data and parts of the Stratigraphic Names database are only accessible if the user enters a valid username and password.

Custodial Access:
Data custodians continue to use their existing ACCESS systems for the day-to-day management of local datasets. However they may also choose to use the specialist tools or the COGENT intranet

system for accessing the corporate repository.

Spatial Data

Spatial data is a combination of AUSLIG "background" data (roads, rivers, Local Government Areas etc.), data from the Department's Titles Administration System (TAS) and site coordinate data that is maintained by the various COGENT data custodians in SDE.

Attribute data…

It was decided that custodians currently using ACCESS databases would continue to use them as many had developed complex applications, performing high level analysis.

However, the ACCESS data must be uploaded to ORACLE at regular intervals so that non-custodial personnel can access and make use of the data.

Where ACCESS databases were not available, (eg, Coal and Petroleum Boreholes and Stratigraphic Names) specific intranet applications were developed that allow data entry and editing in ORACLE.

Benefits …

The Geological Survey's core business includes Regional Mapping, Landuse Enquiries and answering client queries, in particular from the exploration Industry. By providing an easy to use tool to access all geoscientific data held throughout the Department, COGENT facilitates much of the Survey's business. Being able to easily determine what data is available will be of particular benefit to personnel handling client queries. Turnaround time should be significantly improved.

Industry will benefit by having better access to the Department's data, thus facilitating exploration in New South Wales.

All data managed within COGENT conforms to agreed departmental standards.

Who will use it…

The system is primarily intended for use by geologists, geophysicists, cartographers and other departmental personnel. However, a wide range of people will benefit from the ability to clearly and unambiguously determine what data is available for a specific spatial area or for a specific topic.

The system is currently available on the Department's intranet and has been designed for inhouse use. However, future Internet deployment is being considered.

Major components…

HTML Forms:
Active HTML pages with embedded forms are used for all text search activities with results displayed as HTML reports.

Spatial Java Applet:
This allows the user to interactively specify an area of interest to spatially limit the retrieval of data.

Text Java Applet:
Displays the attribute data held in ORACLE.

SQL Web engine:
PL/SQL code performs the bulk of operations within the system. Routines generate the HTML pages, query the database and control access.

Map Engine:
Written in C, the Map Engine retrieves spatial and attribute data from the SDE database and displays it on the Spatial Java Applet and on HTML pages.

Spatial Update:
Also written in C, this code automatically updates the spatial data following an update from ACCESS or from a specialised application.

Hub Loader:
Java and PL/SQL code on the server that initiates a communication with the Node Server, receives data from the ACCESS database, loads it into ORACLE and maintains administrative information. Business rules are enforced and data validation is performed. The Hub Loader is initiated on a schedule or manually. If a schedule is set the custodian can choose to have no input, simply allowing the server to upload data from the PC on a regular basis.

Node Server:
Java code on the custodians PC that extract data from the ACCESS database and passes it to the Hub Loader. Communication with the Hub Loader is via HTTP.

Technology…

The COGENT system is implemented as an intranet solution on the Department's Local and Wide Area Networks (LAN/WAN).

The Department operates a Digital 8200 server running the Digital UNIX operating system.

The data resides in an ORACLE 7.3 database and related spatial data resides in the Spatial Database Engine Version 3.0 (SDE) from ESRI.

Web serving is performed with the Apache Web Server. This is the Department's preferred web server, although other web servers can be supported.

COGENT programs are written using PL/SQL, Java, C, and Perl.

Java programming for COGENT makes use of the Symantec development tools.

All ORACLE database design and data modeling was performed using ORACLE's DESIGNER 2000 tools, except the spatial modeling, which is not supported by this ORACLE product.

A version 4 or higher browser from Microsoft or Netscape is required. This is principally to cater for the use of Java applets.

Contacts…

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Mr Peter Lewis (02) 9901 8372

Geographic Business Systems:

Mr Scott McDonell (02) 9241 5057

Spatial information management via the Internet and intranets

Jonathon Root
Australian Geological Survey Organisation
GPO Box 378, Canberra, ACT 2601

Abstract

The explosive growth in digital geoscience data over the last twenty years has forced a major shift in the way geoscience organisations in both the public and private sectors operate. In the late 1970’s and early 1980’s the focus was on data acquisition and processing. Through the late 1980’s and early 1990’s that focus shifted to data management (including non-digital legacy data), data integration, and data presentation. GIS, image processing and database systems were developed and matured. Today much effort is being expended on systems integration (rather than data integration) and on conceiving information management (rather than data management) strategies.

The next five years will see significant changes in the *way* that geoscience organisations conceive and operate the relationship between information and business. The last five years, culminating in the current industry downturn, have seen a shakeout in the operation of exploration companies. Gone are the in-house drilling crews, and the proprietary geophysical crews (data acquisition roles). Gone too are many of the in-house data processing, image processing and data integration sections. The focus has shifted from gaining competitive advantage from the *exclusive ownership of data*, to leveraging gaining advantage from the *innovative use of information*. Government and other public agencies have a greater requirement for vertical integration but in this sector too, a broadening of client requirements and the societal drive for more effective public institutions will drive change.

Facilitating this trend will be the Internet and its associated technologies. Distributed, Internet-based systems will allow information users to reduce their data discovery, acquisition, processing and management costs while maintaining their need for secure, private and timely access to data. Emerging three-tier IT architecture models will reduce software and hardware costs; and cheaper, more immediate, communication systems will allow effective management of a more distributed geoscience information environment.

Introduction

The emergence and development of distributed systems technologies affords geoscience data and information managers the opportunity to focus their resources on core business. In the past, users of data and information have had to be data acquirers, processors, analysts and archivists; data analysts have been collectors, processors and archivists and so on. Using Internet technologies the potential exists to disaggregate data and information management roles, leading to cost savings and efficiency gains within the geoscience community.

Issues of intellectual property rights, copyright, liability, security, semantics, standards, bandwidth and protocols will dominate in the transition to a networked, distributed, spatial information system. All of these issues are resolvable; but it is critical that they are confronted as soon as possible so that the benefits of recent technology advances can be realised.

At present there is an opportunity for implementing new information management systems. Technologies have matured to the extent that reasonably educated assumptions can be made about their near-term evolution, and volumes of data have reached a critical mass without yet overwhelming managers. This is likely to change very shortly with a wave of new data in the form of multi-spectral satellite data, temporal studies, recently digitised legacy data, and a general increase in resolution as data acquisition systems become more advanced and signal-noise ratios improve.

History suggests that the information revolution will be more about changing the *way* that we work than about simply adopting new technologies. Applying Internet systems to current models of work will lead to more inefficiency, not less. The challenge before us is to change the way we conceive information management to account for the potential of new systems and concepts of work.

Information management

In order to clearly define the potential for reducing costs and improving efficiency through applying Internet technologies to the management of spatial information, it is first necessary to consider an information management model. In this respect spatial information is no different to any other kind of information.

Figure 1 describes an iterative information management model commencing with an analysis of need and concluding with the distillation and distribution of knowledge. Information users decide what information is required to meet a particular need; they then determine whether or not such information already exists. In the case were information is available, all that is required is that the user acquire the information, and the right to use it for a particular purpose. If the information is not available, then the user must acquire, process and interpret data, in order to derive the required information.

Archiving is an important aspect of any information management model, and it is important that information, when archived, remains accessible, either online or near-line. As such, archives should be viewed as *active*.

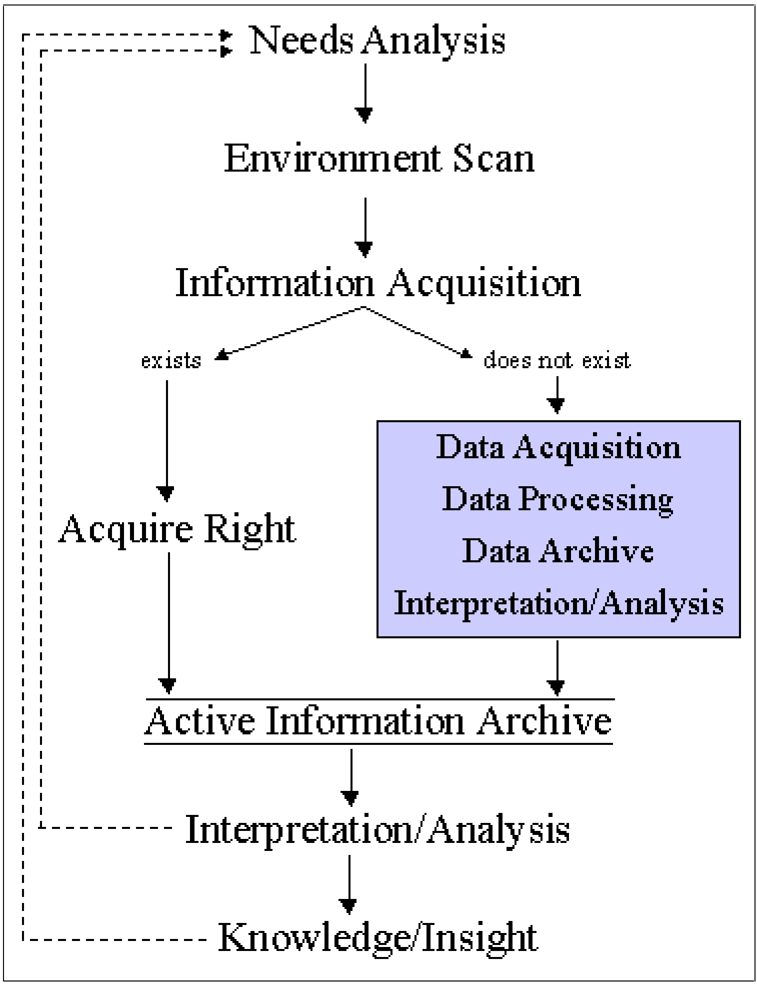

Figure 1. An iterative information management model.

The ultimate aim of the information management cycle is to derive knowledge from the interpretation or analysis of information. The knowledge so derived is distributed to users and also feeds back into the information process, suggesting new information requirements, and potential sources of information.

The application of Internet technologies

The Internet is best described as “an interconnected global computer network of tens of thousands of packet-switched networks using the Internet protocol.” (Werbach, 1997, p10). In considering the potential benefits and implementation paths of Internet technologies we need to view the Internet as nothing more than a network. The level of hyperbole surrounding the Internet, although decreasing, is still sufficient to distract information managers from the fact that the Internet is a *distributed*, *interoperable network*.

At present the dominant architecture in geoscience organisations in Australia is desktop-based. That is, the dominant platform for deploying the software used in the day-to-day business of geoscience practitioners is a PC, or Macintosh, or, to a lesser extent, a Unix Workstation. Software is most often loaded directly onto the desktop with a separate set of binaries for each user. In some cases, this architecture includes a data server if the volumes of data in use exceed the practical capacity of the desktop. The common desktop architecture is shown in or Figure 2.

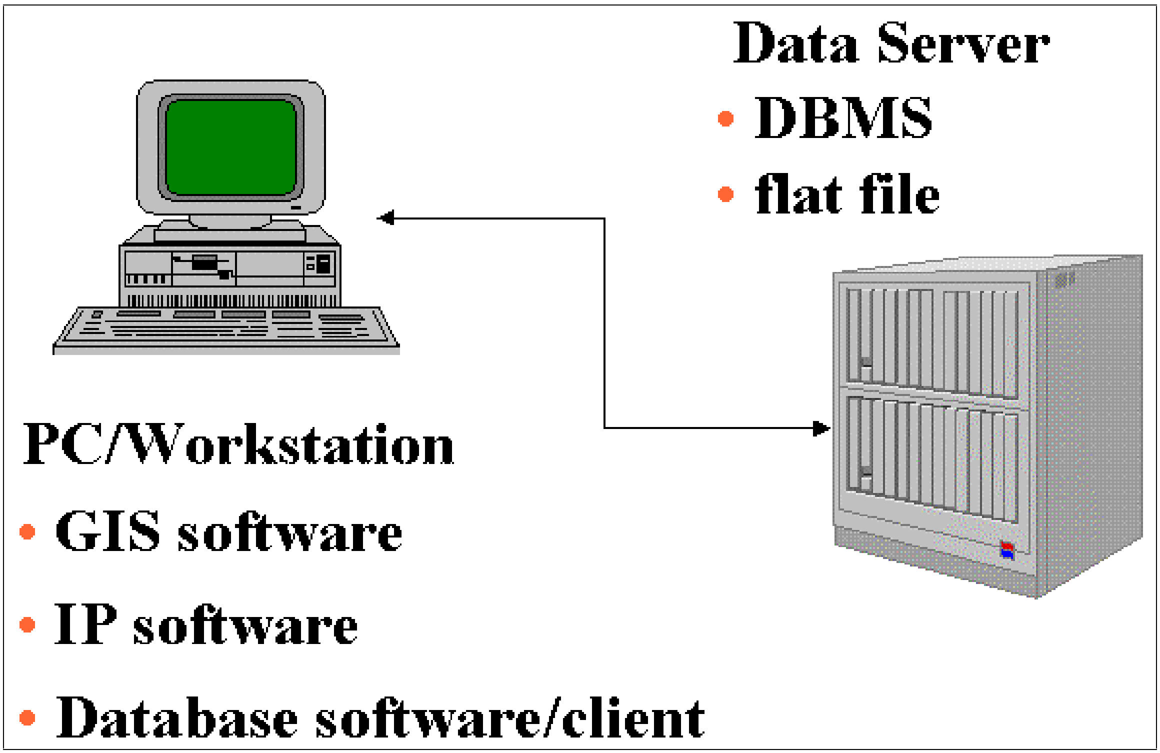

Figure 2. Desktop-centric architecture in common use within geoscience organisations.

The implementation of distributed, interoperable systems based around Internet technologies suggests a separation of the common functions of IT systems into data server, application server and client. This is commonly referred to as three-tier architecture and is described in Figure 3. Examples of common geoscience applications running on Internet systems are shown in Figures 4 and 5 (see Root & Chopra 1997 for further examples).

Depending on the requirements of an organisation, the three-tier architecture may exist only conceptually, with user interface, application services and data repository all residing on a single piece of hardware. It is important, however, that such architecture does exist, even just conceptually, if Internet or intranet systems are to be implemented. The current desktop-centric architecture, where applications and data reside on the desktop, does not integrate well with distributed systems because of the costs associated with managing multiple copies of software and data.

There are obvious benefits to three-tier architecture. These are predominantly in the area of reduced software and hardware management and reduced training costs when rolling out new applications (Udell, 1996, p68-69). There are also potential savings in the area of client service by automating various client service roles and allowing “self-service”. As an example of this second category of saving; in 1997, off an expense base of US$2 billion, Cisco Systems saved US$360 million through the implementation of 6 web-based applications allowing clients to order equipment and look up support databases online – a productivity increase of 18% (Alston, 1998).

Further potential savings can be expected throughout the information management cycle (Figure 1). For example: an organisation principally focussed on the interpretation and analysis of information could expect to reduce their information discovery, acquisition and archiving costs by accessing information remotely from an information custodian’s server. Organisations focussed on the acquisition and archiving of data can expect savings in managing data and in delivering it to clients. Industry-wide efficiencies could be expected through reduction in the occurrence of multiple acquisition of similar datasets (for example: multiple airborne surveys at similar resolution over a similar area) and through a reduction in the number of copies of the same dataset (see Kingwell, 1996, p11 for further examples).

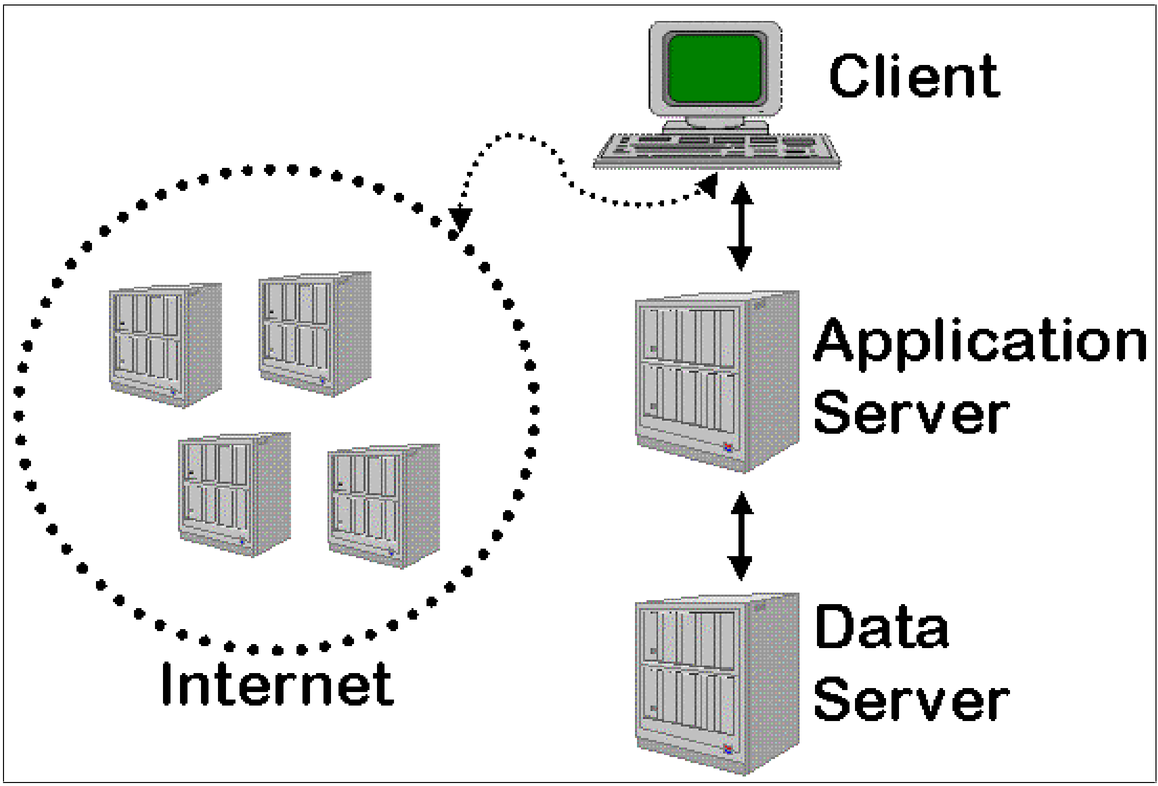

Figure 3. Three-tier architecture with its characteristic functional separation of data, applications and user interface.

Implementation

As with any change of this order, an incremental implementation path is often the best way to start. With Internet technologies the path most often followed is intranet – extranet – Internet. That is; a new system is rolled out within an organisation, via an intranet; the intranet is then opened up to include trusted partners via a Virtual Private network, or an extranet, and finally the system is rolled out to the world via the Internet.

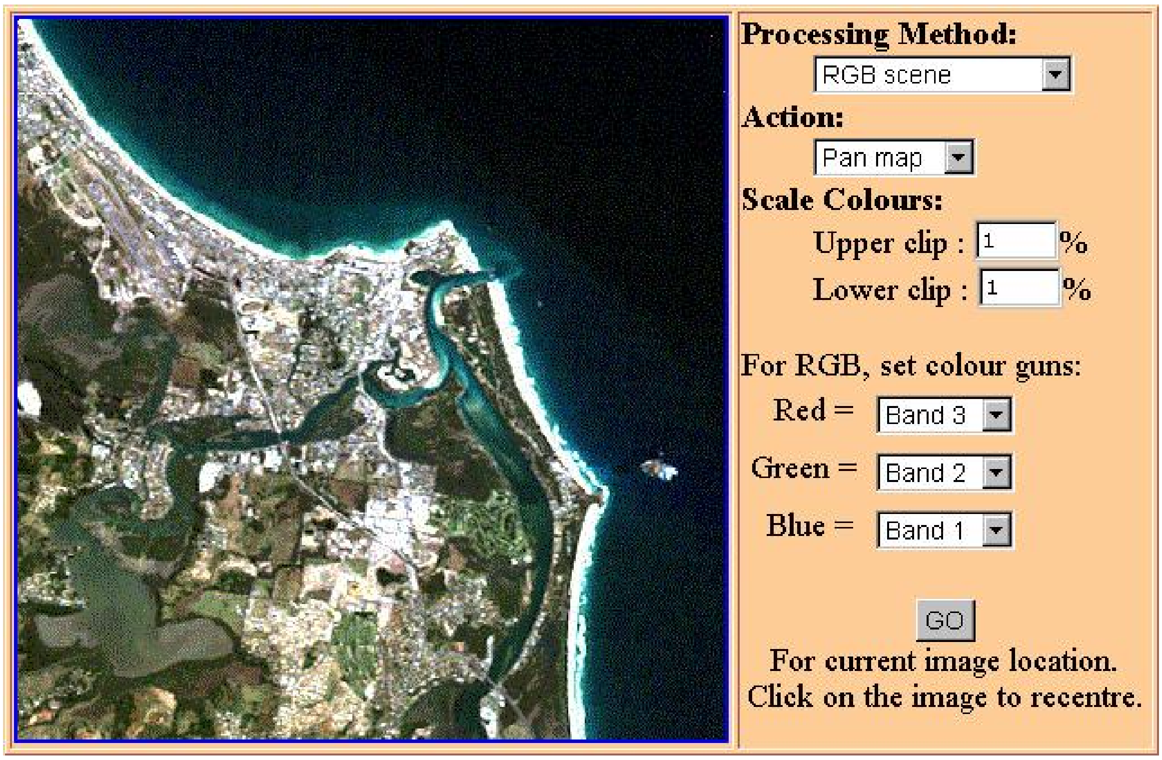

Figure 4. An example of an online image processing system delivering multi-channel satellite TM data (www.agso.gov.au/map/).

This development path allows organisations to manage some of the more complex security and commercial issues that crop up when using Internet technologies. Such issues are minimised in the intranet environment, then expanded in a controlled manner with an extranet, before moving to a full Internet implementation.

Potential stumbling blocks

The common technical hurdles of the Internet – bandwidth, security and privacy - apply to the geoscience community's adoption of Internet technologies. Some are less critical than others are; sufficient bandwidth, for example, can be bought by many organisations (those in outback areas excepted). Because these technical hurdles beset all members of the Internet community, considerable work is going into their resolution. The geoscience sector can expect that developments in encryption, compression, network hardware and protocols will resolve many components of these issues before the geoscience sector is in a position to be held back by them (see for example Halfhill, 1996, Navarette, 1999, Stallings 1996 and Tebbutt, 1997).

The implementation of distributed, interoperable, Internet-based, geoscience information systems presupposes the establishment of a nationally (and preferably internationally) agreed set of standards and protocols for sharing data across the network. Further, there are semantic issues which will need to be resolved. Finally, it is assumed that organisations that commit to a distributed system will have resolved their internal data management issues and have thorough metadata describing their holdings. None of these assumptions are insignificant. Development of national standards will not come easily, and organisations presently grappling with internal data management issues know too well the difficulties and costs involved.

All of these stumbling blocks are resolvable with sufficient commitment. According to Seybold (1996, p11) "… the economics of Internet technology are too compelling to ignore.", and this should drive organisations to overcome the problems which are encountered in developing distributed information systems. Clearly the sooner the geoscience community comes to grips with these technologies and associated issues the better.

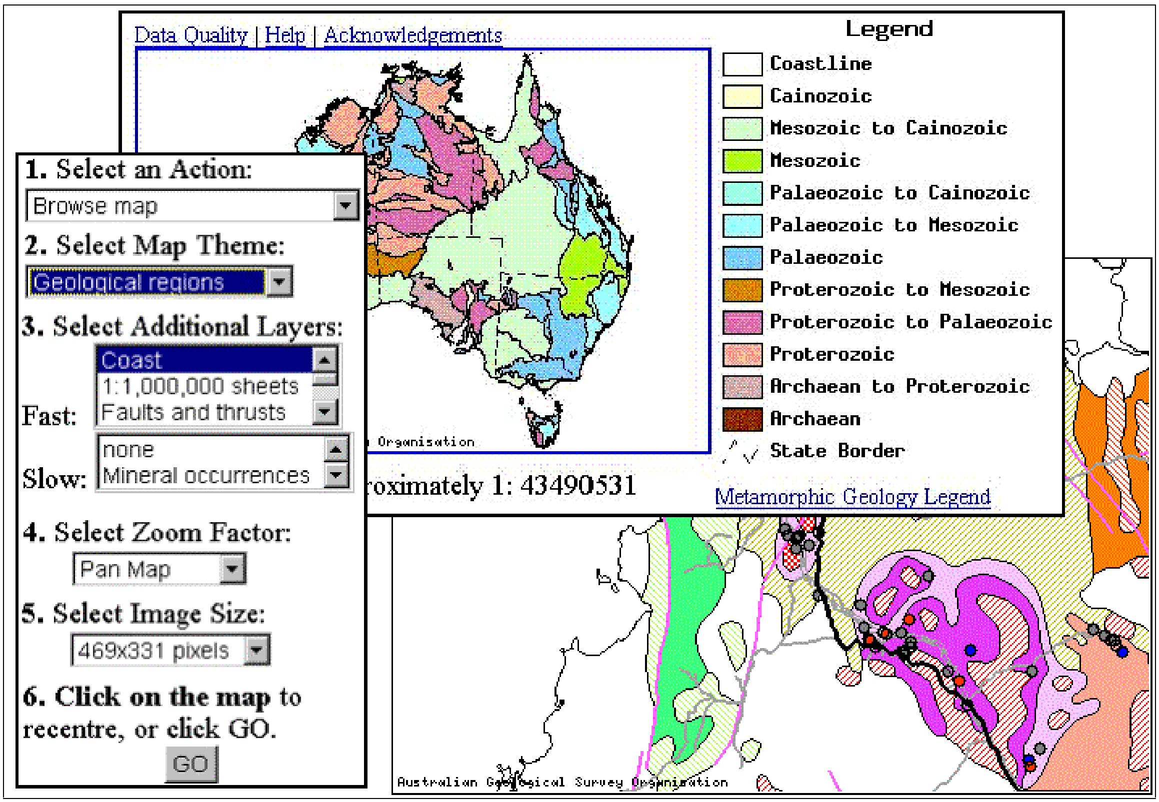

Figure 5. An example online GIS system displaying various layers of geological information (www.agso.gov.au/map/).

Requirements for real benefit

In order to fully realise the potential benefits of Internet technologies, geoscience information managers need to concentrate on two characteristics of Internet systems. Firstly, managers need to consider the potential to achieve cost savings through migrating traditional PC-centric architectures to Internet based three-tier architecture. The separation of data/information from application and from client is an important pre-requisite to realising the potential of interoperable systems. This is not to say that each tier must be physically separate, merely that the three should be independent.

The temptation to run traditional PC-based architecture in parallel to Internet systems is compelling, however this would overcome any potential cost savings and dilute the efficacy of the three-tier system. Clearly it would be unwise to apply the three-tier concept in a doctrinaire fashion; the diversity of functional requirements in the geoscience sector may dictate the necessity for “fat-clients” to run, for example, 3D visualisation systems. However such requirements can still be met within the three-tier conceptual framework and it is important for this framework to have precedence.

The above comments on implementing Internet-friendly architectures imply that system developers need to use the Internet as a development platform for business systems (Seybold 1996, p11). Only by doing this will the geoscience community begin to get the tools they need for distributed information management.

Secondly, managers need to understand the distributed nature of the Internet. Useful here is Metcalfe’s Law, which states: “The value of a network is equivalent to the square of the number of nodes, such that as the network grows, the utility of being connected to it grows exponentially” (Werbach 1997, p6). Figure 6 shows graphically three possible outcomes of using the Internet to manage spatial geoscientific information.

In scenario (a), a number of geoscience organisations implement stand-alone Internet-based information management and delivery systems. Ignoring the benefit of connecting to the Internet as a whole, and the individual “office automation” benefits”, it is likely that the increase in utility of a “geoscience net” with each additional node in scenario (a) will be linear. If some of these nodes are interoperable, as in scenario (b), then we would see some exponential increase in utility, but productivity gains would be dominantly linear. Only in scenario (c) where all systems are interoperable, do we see a significant sectoral productivity increase due to the implementation of Internet systems.

To demonstrate this, consider the benefit to a small exploration company of three organisations, AGSO, AUSLIG and a State Mines Department, “going online”. If all organisations deliver data via independent systems, then the exploration company will still need to download, or otherwise acquire, data from each organisation in order to integrate it. In this case there is little advantage to Internet based delivery; the company might just as well have data delivered by express-post CD-ROM.

If only two of the three organisations have interoperable systems then the exploration company will still have to acquire the data separately in order to integrate it. Only when all three are online does the requirement to integrate offline disappear. If the exploration company has large data holdings of its own, then it will need to embrace Internet technologies, or similar integration problems are likely to occur.

Examples of successful distributed computing systems do exist; for example, NASA conducts collaborative research with industry partners via a collection of data collection, analysis and distribution servers (Udell, 1996, p68-69). The concept of distributed systems implies, however, a high degree of cooperation between all organisations involved; achieving this degree of cooperation is at least as important as overcoming technical issues.

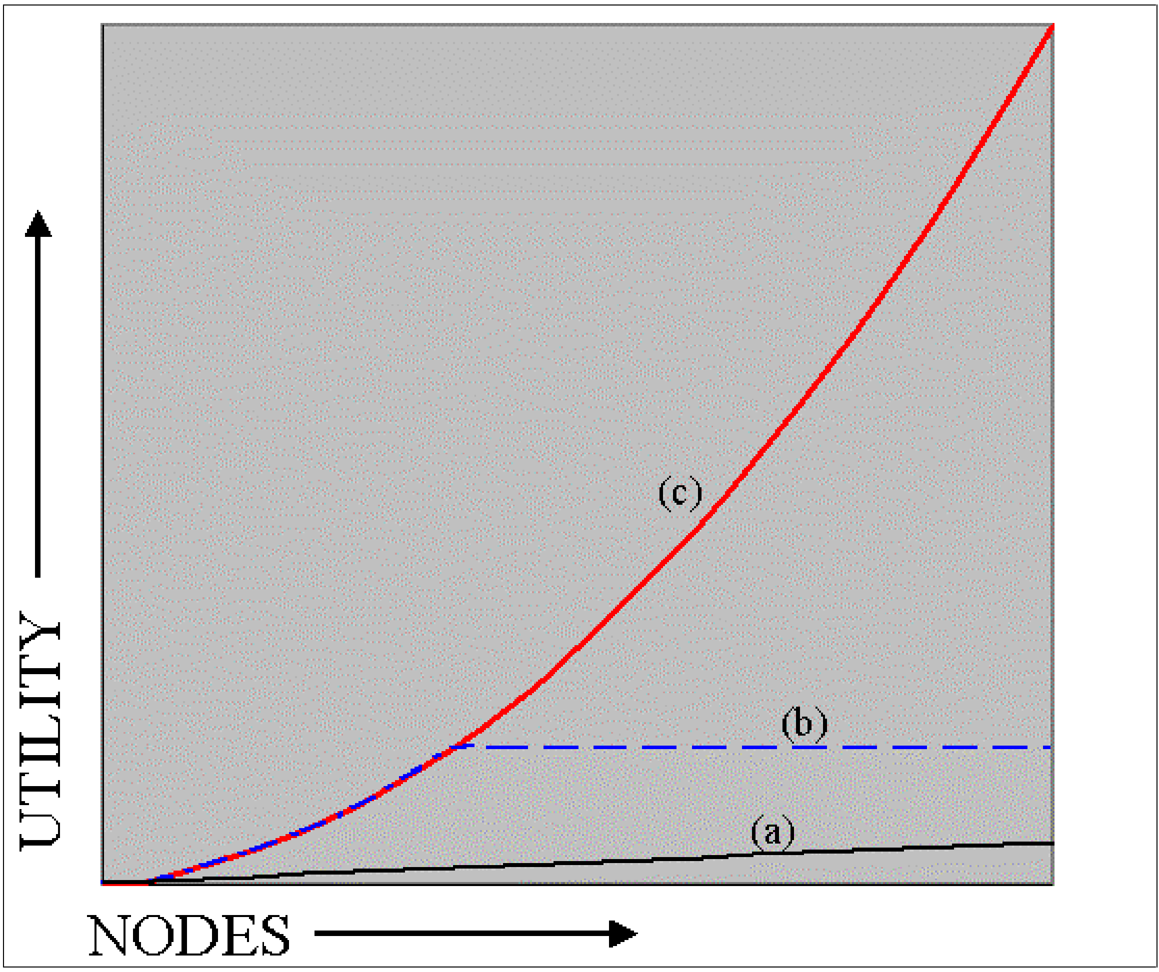

Figure 6. Possible outcomes for the implementation of a national network of geoscience information on the Internet. (a) Isolated nodes providing information, (b) some interconnected, interoperable nodes, many isolated nodes, (c) an interconnected, interoperable network of geoscience information servers.

Conclusions

In considering the evolution of data and information as commodities in the Information Age we can draw an analogy with the evolution of natural resources as commodities through the Industrial Age. Up until the last two hundred years, growth in western economies was related to the acquisition of natural resources; nations fought over the ownership of land and colonised where they could. As the Industrial Revolution developed this position changed, colonies became costly liabilities, the ownership of natural resources *per se* became less important than the good management and efficient use of resources. This process has reached the point where a successful economy, such as Singapore, can exist and grow with few of its own natural resources at all (see Galbraith 1995, p13).

By viewing data as the "natural resource" of the Information Age we can apply these observations to consideration of information management. They suggest that the early emphasis on the jealous guardianship of large volumes of data will evolve to the point where owning and managing large volumes of data will become, as colonies became, a costly and difficult issue. Many would argue that this has already happened.

Managing data is likely to devolve to a small number of data custodians (analogous to resource-based economies), with a specific interest in the data, while the bulk of the information industry concentrates on the analysis and interpretation of information. At the sharp end, practitioners will deal almost exclusively in knowledge, thus becoming the "Singapores" of the Information Age.

This model can only emerge with the development of information management models based on distributed, interoperable systems, where internecine disputes over data ownership are amicably resolved and the privacy and security of transactions can be assured. The growth of the Open Source Software movement is a good example of this process in operation (http://www.opensource.org/index.html, see also Alsop 1999)

Coupling these thoughts with Herriman's (1989) observation that mineral exploration is about "seeing what every one has seen, and thinking what nobody has thought", we get a powerful sense of the relevance of evolving information management models to the geoscience community. There is much work to be done, but the promise is great.

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The DIGS® System—digital conversion of geological reports and client access

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Abstract

The New South Wales Discovery 2000 - DIGS® project, is an innovative, application of imaging and full text retrieval integration applied to a wide range of document types. DIGS® is based on image management and processing technology, delivering both published and unpublished exploration, mining and departmental reports to the desktop in electronic form. A number of processes, including report preparation, indexing, scanning process, quality assessment and storage operations are involved in the generation and retrieval of the geological reports. Development and integration with the GIS based Titles System and other databases is in production. Internet access and digital reporting are being developed.

1.0 The business context

The New South Wales Governments' Discovery 2000 exploration initiative is a six year, $35 million program to enhance mineral exploration in the State. As part of the "Discovery 2000" initiative, the Department established the DIGS® (Digital Imaging Geological Survey System) project, involving digitising the entire GS Report collection of legacy reports and all new reports (either digital or hardcopy) as they are submitted.

2.0 The objective

The rationale for the DIGS® system stemmed from the need to more effectively manage the information resources of the Department of Mineral Resources. These resources are centered on the "GS System" - a collection of geological and geophysical reports dating back to the beginning of systematic geological investigations in NSW in 1875. Past methods used to access the GS report collection have included punch cards, a bibliographic cross-reference card system, microfiche and aperture cards.

The more effective use of this unique database was paramount in the design criteria developed for the DIGS® system. Prior to the establishment of the DIGS® project, the manual GS system had a number of shortcomings mainly due to poor access and the inability to preserve the quality and integrity of the information. One of the prime concerns in the design phase was the ability of the new DIGS® system to provide access for multiple users throughout NSW. This was previously not possible without considerable delays involved in physically transporting hard copies of the reports to various Departmental offices around the State. A second major objective in the design and implementation of the DIGS® system was the capacity to maintain and improve the security of reports from loss and damage.

3.0 Report Conversion Process

3.1 Conceptual Design

According to the objectives of the DIGS® project, the system had to be able to manage data input, data manipulation, storage and retrieval. The challenge was to integrate a pre-existing bibliographic textual database (Minfinder) with a huge volume of scanned images and digital data. Therefore, the new system had to be able to update and manage the textual database (Minfinder), and integrate scanned images and digital data in reports.

In the DIGS® system, the textual database Minfinder uses the Fulcrum a full text retrieval search engine. This is linked with the Tower Imaging System, which handles image storage and retrieval, as illustrated in Fig. 1.

Custom developed Visual Basic user interfaces communicate directly with the system databases. The Minfinder database populated by records relating to the documents is implemented on Fulcrum (full text retrieval software), whilst the document database (which links document indices to their physical locations) is maintained on the Tower system.

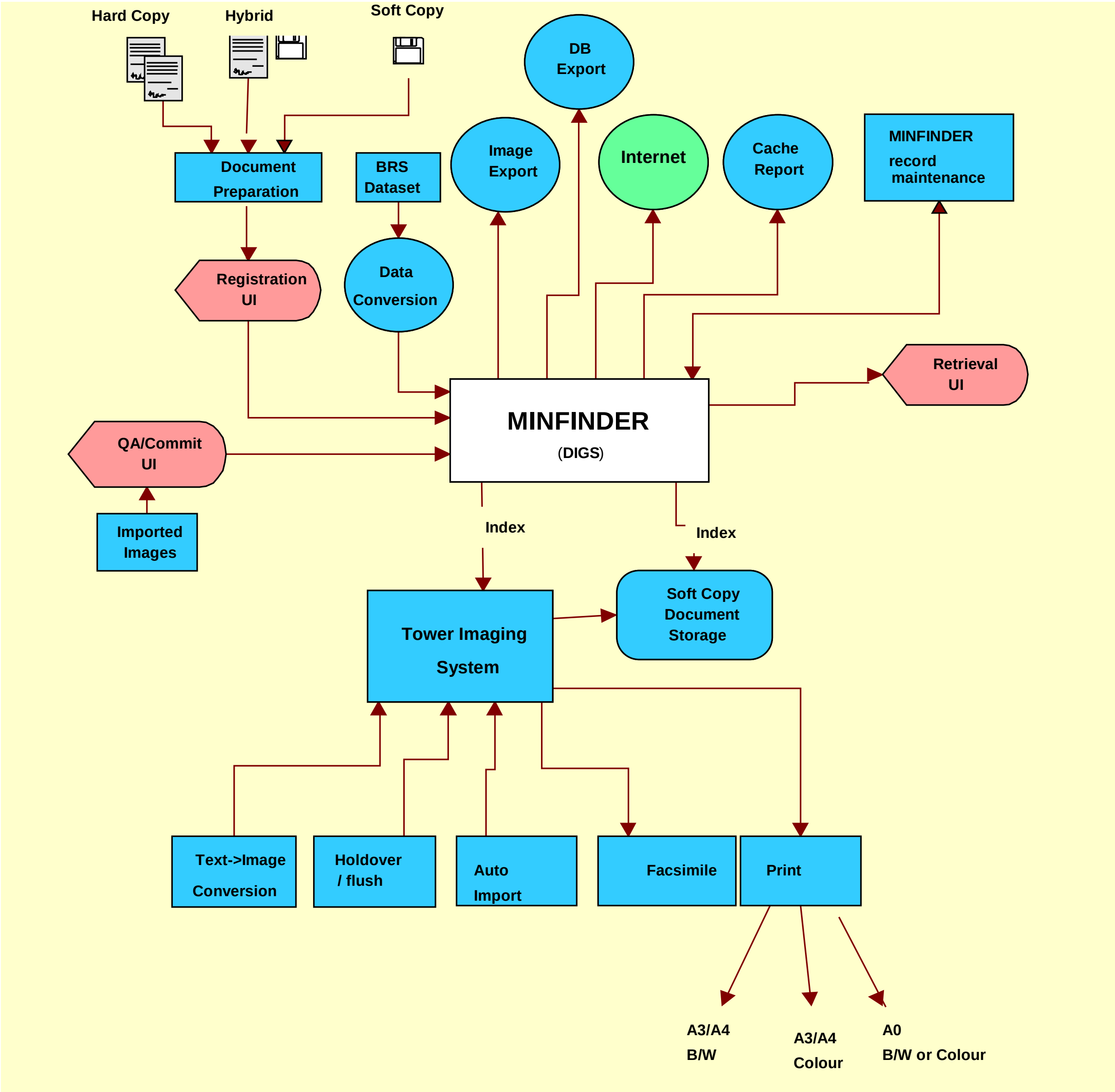

Figure 1. Functionality of DIGS® system

3.2 Database interfaces

To provide both archival and retrieval services the DIGS® system comprises three main interfaces: the *Registration User Interface (Registration UI)*, which is used for registering reports into the system; the *QA/Commit User Interface*, which enables a review of the quality of the documents after scanning before loading into the system and the *Retrieval User Interface*, which allows users to search for and retrieve documents from the system.

3.3 Registration

Staff collect and prepare the GS reports for indexing. They count the number of pages, identify different sizes of each document and ascertain whether black & white, colour or grey scale scanning is required.

Registration of the report is carried out through the Registration UI and is accomplished by keying the required information (some of which has pre-coded information) into a template of the Minfinder summary sheet. The indexing of pre-1996 reports requires the recall of existing Minfinder indexing data using the “get data” option. Additional information such as subject terms and collation page numbers are added by the indexer.

Registration of post-1996 reports is accomplished by direct indexing into the DIGS® system. Information in 16 fields is entered including an abstract of the report, map sheet location, a list of subject terms to describe the aim of the exploration, work carried out and results achieved.

Registration of the document in the report is carried out by entering information into a template. A document can be text, appendix, map etc. Indexers enter values into various fields, such as document type, size, colour and title. At the end of registration a data input control file is created on a floppy disk. A copy of the disk input control file is then sent to the scanning bureau and is used to track documents within the bureau and on their return to the Department.

Exploration and mining companies have been encouraged to supply their reports in digital form which would facilitate the inclusion of the data directly into the DIGS® system without being scanned.

3.4 Scanning

At the scanning bureau the report is disassembled, separating the documents according to page sizes and output types (black and white, grey scale or colour). The document groups are then sent to different scanners. At the completion of scanning, the various parts of the report are reassembled and bound with a simple two hole wire binder with a folder made from “acid free” material. Very large maps may need to be folded and scanned separately and digitally re-stitched. Old and fragile documents are inserted in plastic sleeves prior to scanning. Folded maps may need to be ironed to remove creases prior to scanning.

3.5 Quality assessment

The scanned images are stored on a server at the scanning bureau before loading onto tape. At this point the scanning bureau staff also carry out quality controls to ensure that all the documents have been scanned and are of acceptable quality. In addition, DMR staff carry out an independent, random quality assessment of scanned reports on the Bureau premises. The criteria for quality control is the closeness of the reproduction to the original in clarity, colour, correct orientation, minimal information loss etc. In the case of poor quality black & white originals, grey scale scanning is required. One advantage of the quality assessment process at this stage is that errors can be corrected prior to the images being copied onto tape.

3.6 QA/Commit user interface

The QA/Commit Interface (QA UI) was developed to provide a mechanism for quality control of images and digital data, prior to importing into permanent juke box storage. The interface is used to reject or accept images based on quality. The QA UI is designed to first validate the control file returned from the scanning bureau by checking if it has the same number of entries as in the DIGS® system. Then the number of images contained on the tape are checked against the control files. If no discrepancy is found, the QA UI will proceed to auto-import images into the DIGS® server for quality assessment at the DMR workstation. It relays the images to the database as part of the hold-over and flushing mechanism which places images and digital data onto the optical disks in juke boxes.

4.0 Operation and data retrieval

4.1 Retrieval user interface

The Retrieval UI, which is designed to be a user-friendly system, possesses a full text retrieval capability. It allows searching across text documents within index fields in the Minfinder database and viewing documents either as images or digital data after they have been committed to permanent storage in the DIGS® system.

4.2 Display, print and export of images

In order to display images of documents a separate Image View Screen is used. Views of images can be altered by zooming or rotating the image and include a scaleable ruler, zoom factor and page indicator. Customised keys provide shortcuts when working with images.

The Department offers a number of services to the public and Departmental users of the collection. Access to Minfinder and the corresponding open file reports is provided to external clients. Some of these services include: on-line access to Minfinder the provision of hard-copy reproduction services (both in-house and commercial copying), on-line access to reports in image format at the Department’s head office, plus on-line ordering of digital or hard-copy output of report images and associated data through a local reproduction bureau.

5 Future developments

5.1 Internet access and regional offices

In future, the Department will provide on-line or dial-in through the Internet access to the reports for offices in regional offices and clients at remote sites. A broker or intermediary system could be used to obtain indirect access to the head office network. The open file images and digital data held in DIGS® could then be delivered in two ways, firstly as an interactive service with the images converted to the GIF or JPEG format and delivered directly to a Web browser page by page. Alternatively, after searching Minfinder and then locating the report users could compile a list of documents within a report and request delivery of these documents at a later time.

5.2 TAS integration

The Titles Administration System or TAS is designed to provide a GIS graphic viewing and inquiry system, which includes both spatial and non-spatial mining title data. The system provides functions to search and inquire on mining titles, applications, etc. and display their locations graphically.

TAS is integrated with DIGS® in order that spatial searches could be conducted on the titles system. DIGS® is used to locate and view reports and two fields are identified which could be used to locate common information in both systems. For example, the map sheet field and the tenement (exploration licence number) field in Minfinder could be located spatially in TAS. In order for the system to operate, a spatial search is conducted either by map sheet and/or licence number using the TAS spatial search engine. The TAS application collects key information and then runs the DIGS® application, by passing this key information as search parameters. The results of this search are then displayed via the DIGS® retrieval interface. The development of this application interface that allows connection to the TAS system will also allow access to other systems such as the drilling (Intersect) database providing the spatial data has a text attribute that will allow searching of the Minfinder database. For example a drill hole database which has been located spatially could be connected to the DIGS® system using a report number and document number to locate the logs for a particular drill hole.

5.3 Future incoming report format

Submission of exploration and mining reports at the moment is predominantly as hard copy. However, digital lodgment is on the increase. The Department is currently developing standards for the submission of digital data and reports in association with other States so that a minimum national standard can be developed. There is a basic structure and sequence of documents within a report even though the information may come from a variety of sources (e.g. cover page, contents page, text, appendix, maps etc.). There are two important issues to address when dealing with digital reporting. Firstly, it is necessary to maintain the integrity or coherency of the original report, and secondly, to ensure that raw ASCII tabulate data is available in a form that can be used eventually by third parties..

Therefore in order to maintain the integrity of the report, companies will need to provide data files and digital images that conform to guidelines in terms of file format, media and naming of files. Proposed formats could include PDF format for text (report body), ASCII for tabular data, and Tiff or JPEG for maps. Presently one format can not be used to maintain the integrity of the entire report. Media types could consist of floppy disks or CD-ROM while the file naming convention could use names such as figure1.tif or map1.jpg or report text as text.pdf. Using a model such as this reports can be directly integrated and viewed within DIGS®. It is understood that the PDF format cannot be used for maps larger than 1143mm by 1143mm so the Tiff or JPEG file format will be required for larger maps. It is expected that eventually industry will be requested to report in digital form.

6.0 Conclusion

The new computerised DIGS® database system is successfully replacing the current hard copy library system and the old Minfinder application. This new system allows both departmental and public users to search for and retrieve new images of documents, once they have been scanned, registered and committed to the system. It allows multiple on-line access to all reports at DIGS® workstations throughout the Department and within the Minerals and Energy House public access library and eventually the Internet.

DIGS® offers major advantages in respect of ease of use, simultaneous access to documents, document quality, high speed multiple access capability, database and application integration, extensive search capabilities and reproduction facilities. The integrity of the data in the collection has been secured, the management of the confidential reports improved and an invaluable asset preserved for future generations.

Acknowledgements

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AGSO's catalog of everything

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Abstract
With the increasing emphasis on electronic rather than paper products, the need for good metadata is becoming patently evident. The new 'AGSO Catalog' is designed to address this problem at the corporate level. Developed from the AGSO Products Database, the AGSO Catalog encompasses most of AGSO's outputs, datasets and resources, which it does with the help of various intranet and Web interfaces. Projects or authors must initiate Catalog entries, for without an acceptable metadata entry a product cannot be sold by the Sales Centre, or permission to publish will not be granted. The Catalog is the key to future systems of information distribution and sales. It will permit us to go directly from the metadata to the electronically stored objects, thus enabling automated information distribution and electronic commerce.

Introduction
The speed with which we are changing from a paper-based information society to an electronic one is catching many by surprise. Most of us rely less and less on letters, paper documents, maps, photographs and faxes, and more and more on email, Web sites, electronic documents, spreadsheets, GIS files and digital images. Our PCs and server filing systems are rapidly filling with files of various sorts, but the means to keep track of all this is not keeping pace. We all know how easy it is to lose files in a fractal-like maze of hierarchical directory systems, but we persist in relying on computer filing systems that are now 20 years out of date. There is a real danger that information that was previously preserved on paper, and stored in libraries, registries, archives, etc., will now simply evaporate like water in the desert.

Fortunately, the systems to handle this great proliferation of electronic information are becoming available in a variety of guises. Perhaps the best known of these, apart from computerised library catalogues, are the electronic registry systems such as IBM's 'TRIM' system, that allow organisations to permanently file electronic correspondence and attached documents against the proper metadata. Also beginning to appear are so-called 'enterprise portals', which are accessed via intranet and Web interfaces. It may come as a surprise to some that electronic information can now be stored more safely than paper records. Of course, this pre-supposes that sufficient attention is given to backup and disaster-recovery procedures. Nevertheless, we must still devote resources to capturing the metadata that allow us to find that one critical item amongst a host of files and other objects.

In the absence of any ready-made commercial system designed to deal with the great variety of electronic files that AGSO handles, we have decided to set up our own minimalist metadata catalogue - the 'AGSO Catalog' (the spelling is deliberate) - which first and foremost does the things we want it to do. This is not an entirely new system, but rather an extension of the existing AGSO Products Database. The Catalog is designed to handle not just products, but datasets, documents, articles and other forms of work output, as well as corporate resources in general. In addition to providing a foundation for electronic commerce and information distribution on the Web, the Catalog will eventually point users to objects without the need to know the objects' location on the AGSO network. Fundamentally changed, however, are the business procedures designed into the Catalog and its built-in links to AGSO's existing ANZLIC-compliant spatial metadata system for spatial datasets and products. The Catalog is scheduled for trial in April-May 1999 and for production by 1 July 1999, at the latest.

The AGSO Products Database

The Products Database has existed on the AGSO Web site for some years (*http://www.agso.gov.au/information/structure/isd/database/products.html*), and has more recently been upgraded with a secure product-ordering system (Fig. 1). It started life as a static file extracted from the BookSCAN point-of-sale system used by AGSO's Sales Centre, but this file rapidly went out of date because no one had the job of updating it. An Oracle database was then built from BookSCAN data that was manually cleaned and massaged as far as practicable. This database is updated each month from files extracted from the BookSCAN system. These files undergo a largely automated procedure for cleaning and improving the metadata, before it is added to the database. The database is queried via an HTML Web form and an HTML report is generated dynamically by a program written in the SQR (Scribe Technologies) database reporting language. Ordering of products takes place via a secure system that automatically generates encrypted email messages to the AGSO Sales Centre.

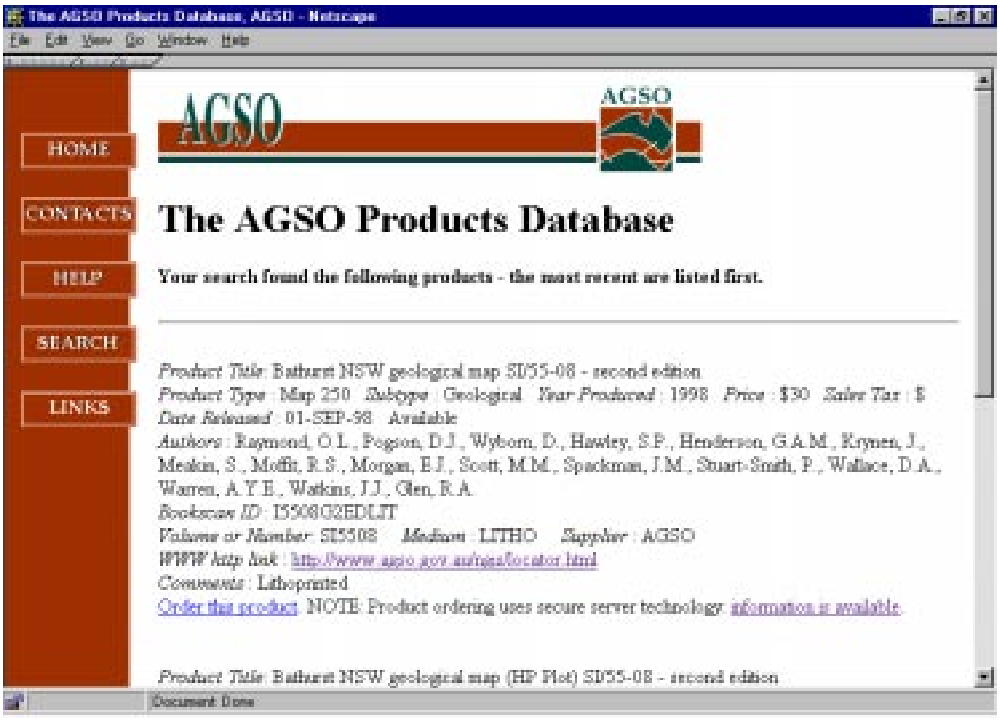


Figure 1. An example of a Web report from the AGSO Products Database. Products can be ordered online by clicking on the '<u>Order this product</u>' link. A similar interface, but with more information about the product (including abstracts and thumbnail images) will apply to products in the AGSO Catalog.

The existing Products Database works well as a Web query and ordering system, but the metadata in it still leaves something to be desired. Product metadata are currently entered by sales staff, who are not always in a position to know all the relevant product details. They use the BookSCAN System, from Barcode Solutions Pty Ltd, Sydney, which is a small-business system running on a PC server. BookSCAN was designed mainly as a point-of-sale system for book shops. It lacks facilities for spatial metadata, full authorship, abstracts and other useful information. Nevertheless, we can derive the bounding lat/long rectangle of maps during the semi-automated processing that takes place during transfer of product metadata from BookSCAN to the Products Database. The product can then be spatially located via the map interface provided by the @ngis Data Locator (Root & Chopra, 1997) on AGSO's Web site (*http://www.agso.gov.au/ngis/locator.html*). Additional information can be added to the Products Database by any AGSO staff member with an Oracle logon, but this occurs only infrequently because the data entry forms are not easily accessed and are not very user friendly.

Although the Products Database is being replaced by the AGSO Catalog, it will still exist on AGSO's Web site in a similar but enhanced form. In essence, the Products Database becomes a subset of the Catalog with client query facilities and a shopping basket mechanism.

The AGSO Catalog

The AGSO Catalog differs from the Products Database in several fundamental respects :-

- The Catalog is designed for metadata in general, not just product metadata.
- It includes papers and articles by AGSO staff in outside journals, magazines, etc.
- A Catalog record can be initiated by most AGSO staff, authors, project leaders, etc.
- The main data entry interfaces to the Catalog will be via the AGSO intranet.
- Several QC checks and signoffs are generally required before an entry is made public.
- Thumbnail images and whole documents as PDF files may be attached to a record.
- ANZLIC-compliant metadata on spatial datasets may be linked to a Catalog record.
- As a spinoff, the Catalog provides a mechanism for online publishing via the Web.
- The Catalog gives access to a second tier of metadata for some classes of object.
- The Catalog will ultimately allow direct access to products stored as computer files.

The structure of the AGSO Catalog database (Fig. 2) is relatively straightforward, with a table (AGSOCAT) for Catalog entries and some subsidiary tables for authors (CATAUTHORS), projects (CATPROJECTS), attached files (CATFILES), documents (CATDOCS), images

(CATIMAGES), and Web URL addresses (CATURLS). The CATDOCS table currently has pathnames to PDF document files, while the CATIMAGES table actually stores GIF and JPEG thumbnail images for Web display. Catalog entries are classified according to a two tier system, comprising types (CATTYPES) such as ‘AGSO Publications’ and subtypes (CATSUBS) such as ‘AGSO Records’. Any number of theme words (CATTHEMES) may be attached to a Catalog record and the medium on which a Catalog object is stored is also recorded (CATMEDIA). Since AGSO also sells maps and other items produced by outside organisations, — such as state geological surveys and mine departments — there is a lookup table (CATSUPPLIERS) of ‘supplier’ organisations for these items.

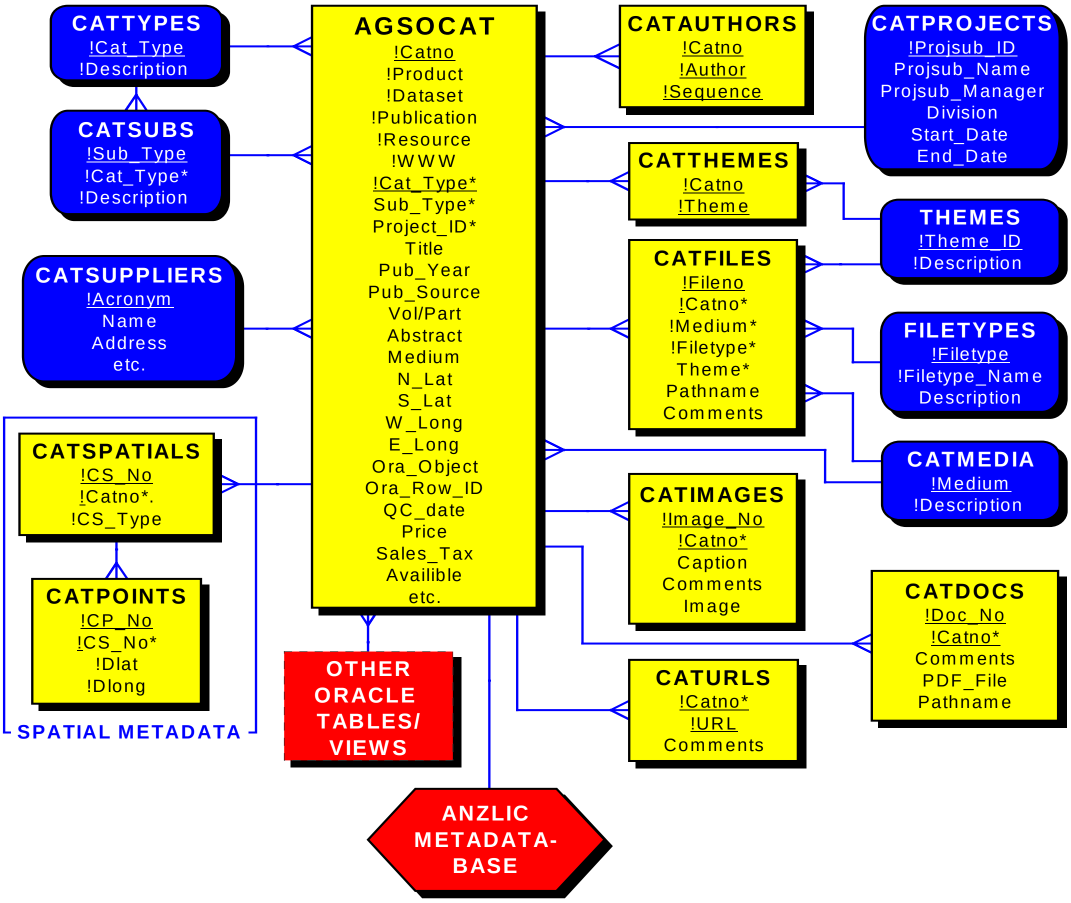


Figure 2. A table-relationship diagram of the AGSO Catalog. The main data tables are indicated by square boxes and lookup tables by rounded boxes. The ‘many’ end of many-to-one links between tables are marked by the ‘crow’s feet’.

Spatial metadata

Spatial metadata are handled in two ways. Conventional fields for a bounding rectangle in decimal degrees of latitude and longitude are included in the main AGSOCAT table. These fields are perfectly adequate for the majority of objects in the Catalog such as maps and images. However, the Catalog also has two special tables, CATSPATIALS and CATPOINTS (Fig. 2), for Catalog objects that may be associated with one or more irregular polygons, lines or points. The former table determines the type of spatial object (point, line or polygon) while the latter one contains all the nodes or points making up the object. By way of example, one Catalog record can be attached to multiple irregular polygons, the crooked loci of a number of seismic sections, all the sample points in the ROCKCHEM database, or any combination of all these.

Spatial metadata can be entered into the two specialised tables by hand, but they will more normally be entered via bulk insertions from other AGSO databases using the SQL command-line environment in Oracle. Spatial metadata from both sources will be regularly extracted from the Catalog in the form of a flat file for querying via the Web maps generated by the @ngis Data Locator (Root & Chopra, 1997). The same mechanism has been used for spatial queries using the bounding rectangles from the Products Database.

Web and intranet interfaces

External clients will view publicly accessible records in the Catalog via several Web interfaces, including a query and ordering facility similar to the current Products Database (Fig. 1), an AGSO publications interface and a datasets interface linked to GEOMET — AGSO's ANZLIC-compliant metadatabase for spatial datasets. GEOMET is currently visible in proto-type form on AGSO's external Web site *(http://www.agso.gov.au/information/structure/isd/ database /metadata.html*). The products facility has priority, however, and this should be up and running by May 1999. These interfaces will use the same technology we are currently using to display AGSO's databases on the Web. That is, an HTML query form collects the client's selection criteria, which are then passed to an SQR program that queries the Oracle database through the AGSO firewall and formats a dynamic HTML report for display on the client's browser. SQR is a 4^{th-}generation database reporting language from SQRiBE Technologies that AGSO has used for over ten years. The product ordering system is very secure, as it uses Netscape's 'Secure Sockets Layer' and encrypted email messages to pass orders through the firewall to AGSO's Sales Centre.

In addition to using the facilities available on the external Web site, AGSO staff will use Oracle GUI Forms (Fig. 3), menus, and reports on the intranet to enter and maintain metadata in the Catalog. Oracle's Web Application Server is now being used to display these forms on intranet browsers, but this 'thin client' solution has some problems and is still rather slow to start. We are closer to the 'bleeding edge' than we thought, as AGSO seems to be the first large organisation in Australia to attempt to place Oracle forms on browsers such as Netscape Navigator or Microsoft Explorer. However, we anticipate these problems will be overcome soon and a trial of the Catalog can commence in April 1999. An alternative route would be to use X-Windows emulators, such as Hummingbird's Exceed software, which is what most staff now use to access Oracle databases. This solution is also somewhat slow in the start-up phase, and is less than ideal for a system designed to be used routinely by many staff members.

In the longer term, we expect that Oracle forms will also be used on AGSO's external Web site, but the Oracle licence required to do this is still very expensive. The cost will probably come down as Web-commerce solutions become more widely used.

The initiator's form

The data entry form that most staff in AGSO will use on the intranet will be similar to the prototype Initiator's Form (Fig 3.), which was developed using Oracle Forms 4.5. This form will be translated to Oracle Forms 5.0 before it can be placed on AGSO's intranet. Any member of staff with a project number and a personal logon to the corporate Oracle system can initiate a Catalog record. Whether this record eventually proceeds through to the Catalog's public Web interface depends on several quality control and signoff procedures. Except in the case of external papers, publications and articles (see below), the initiator does not have the final say on when a record is declared fit for public consumption. On the whole, we trust initiators to supply accurate metadata. After all, the initiator is usually the person who knows most about a catalogued object, and it is in their own interest to advertise their outputs as accurately and as soon as possible. However, most entries for products and datasets will require vetting for metadata quality, completeness, and signoff by a 'metadata manger'.

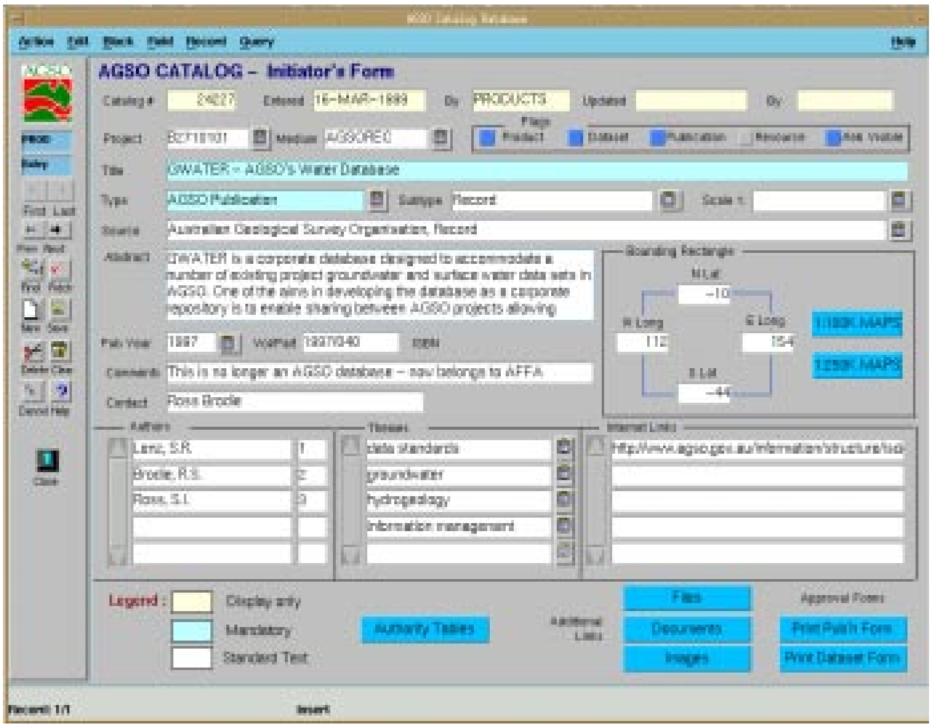


Figure 3. A prototype version of the AGSO Catalog Initiator's Form, which is designed to be used on the AGSO intranet by many AGSO staff members.

Products, datasets and resources

The Catalog classifies its entries into products, datasets, resources and publications, which are not mutually exclusive and are indicated by the checkboxes in the form illustrated in figure 3. A product is defined as anything sold by AGSO's Sales Centre. Most AGSO publications are both products and publications. All released products will be visible on AGSO's Web site — in much the same way as products are in the existing Products Database, described above.

AGSO's Sales Centre has the job of releasing products for public consumption. Depending on the particular product, Sales Centre staff first make sure that permission to publish has been obtained, that the product has passed divisional and corporate quality-control and metadata checks, and that ministerial approval has been given. Using a 'Data Administrator's Form' (similar to Fig 3), they enter the price and sales tax into the Catalog and set the 'Web Visible Flag'. As soon as the 'Web Visible Flag' has been set the product can be seen on the Web.

Datasets include such things as spreadsheets, GIS files, processed images, databases and database extracts. Datasets tend to be static, in the same sense that publications are static, as they are produced on a particular date. Datasets can also be products, publications and resources. Datasets can be maps, GIS data packages, databases or database extracts that have been frozen at some points in time, processed images, seismic sections, drill hole logs, and a whole host of other objects that are usually static in nature,

Resources are usually datasets that are useful corporately, or are otherwise needed in the course of AGSO's work. They typically include CD-ROMs, topographic maps, satellite images and geophysical data that we buy in from elsewhere for inhouse use. They can also be AGSO products and datasets. AGSO's large collection of Landsat images on magnetic tape cartridges are both resources and datasets. Specialised software packages can also be resources, as are diagrams, maps and photographs that are produced inhouse for incorporation into products, but are capable of being reused.

'GEOMET' — ANZLIC-compliant metadata

The problem of supplying metadata on spatial products and datasets that conforms to the ANZLIC metadata guidelines (ANZLIC, 1996) has been solved by setting up a separate database called 'GEOMET' that is linked to the AGSO Catalog. GEOMET has been visible on AGSO's Web site for some *time (http://www.agso.gov.au/information/structure/isd/database/metadata.html*), but only in prototype form, and with metadata mainly from 800 geological maps. The descriptions entered in some of the fields are highly repetitious. We have now set up a friendly data entry form for staff to use via X-Windows (Fig, 4). This will be made visible on the intranet, when that method of distributing forms goes into production.

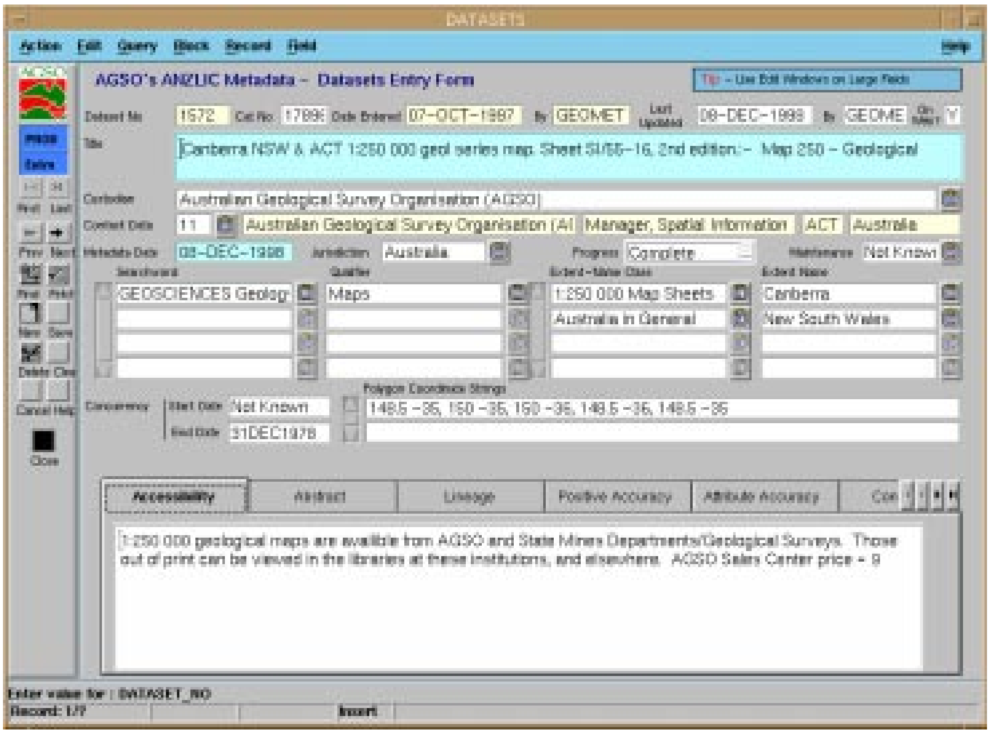


Figure 4. A preliminary Oracle Forms 5 version of the GEOMET metadata entry form, designed for use by staff who know about the ANZLIC metadata standard.

GEOMET has been designed to the exact ANZLIC specifications (Fig. 5), with the exception of authors names, which are not a part of ANZLIC 'Page 0' specifications. ANZLIC-compliant metadata is generally required for all spatial products and datasets such as geological and geophysical maps, GIS datasets and processed images. However, the entry of this metadata is somewhat tedious, and we do not think it is necessary for all entries in the AGSO Catalog to have corresponding GEOMET entries. Those that do will be entered by staff who have some training in the ANZLIC metadata guidelines, and not by AGSO staff in general. Later versions of the data entry form illustrated in Fig. 4 will include a button for automatically copying across the relevant from a pre-existing AGSO Catalog record.

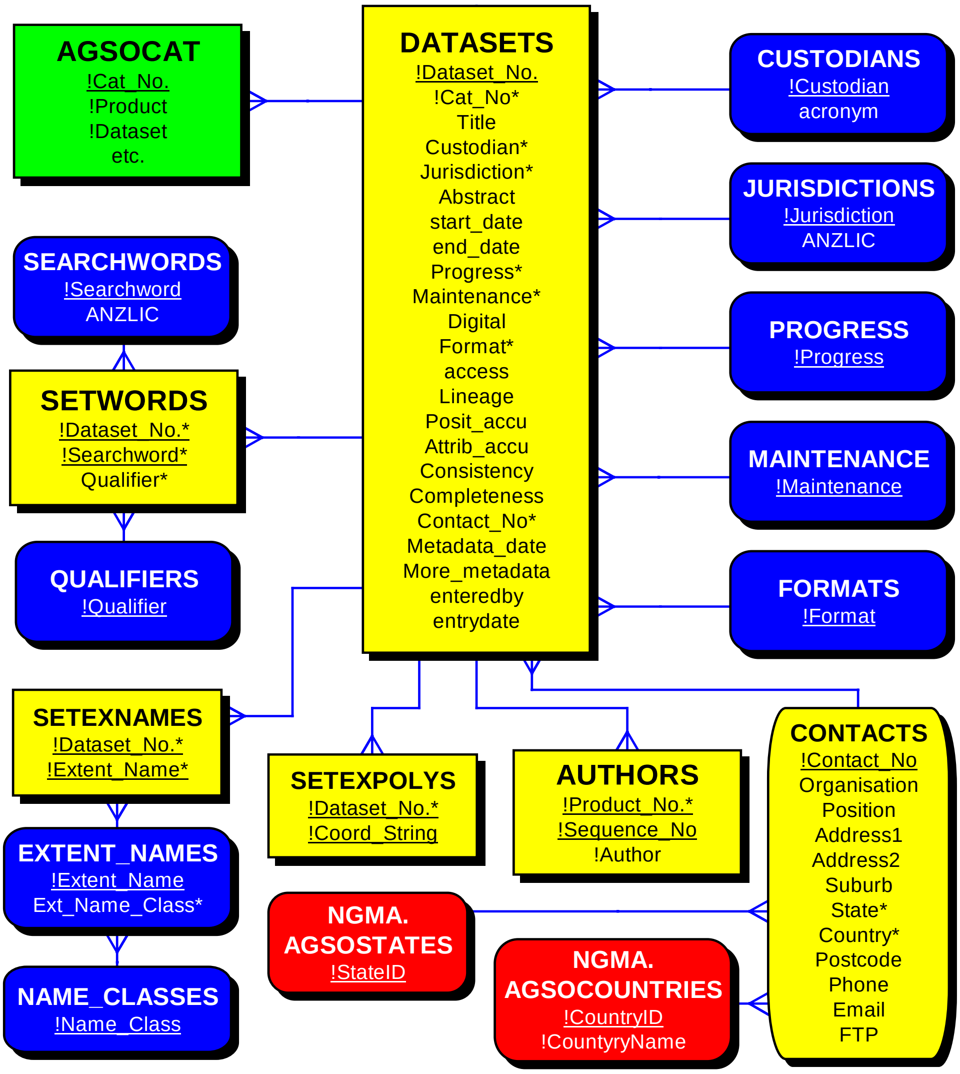
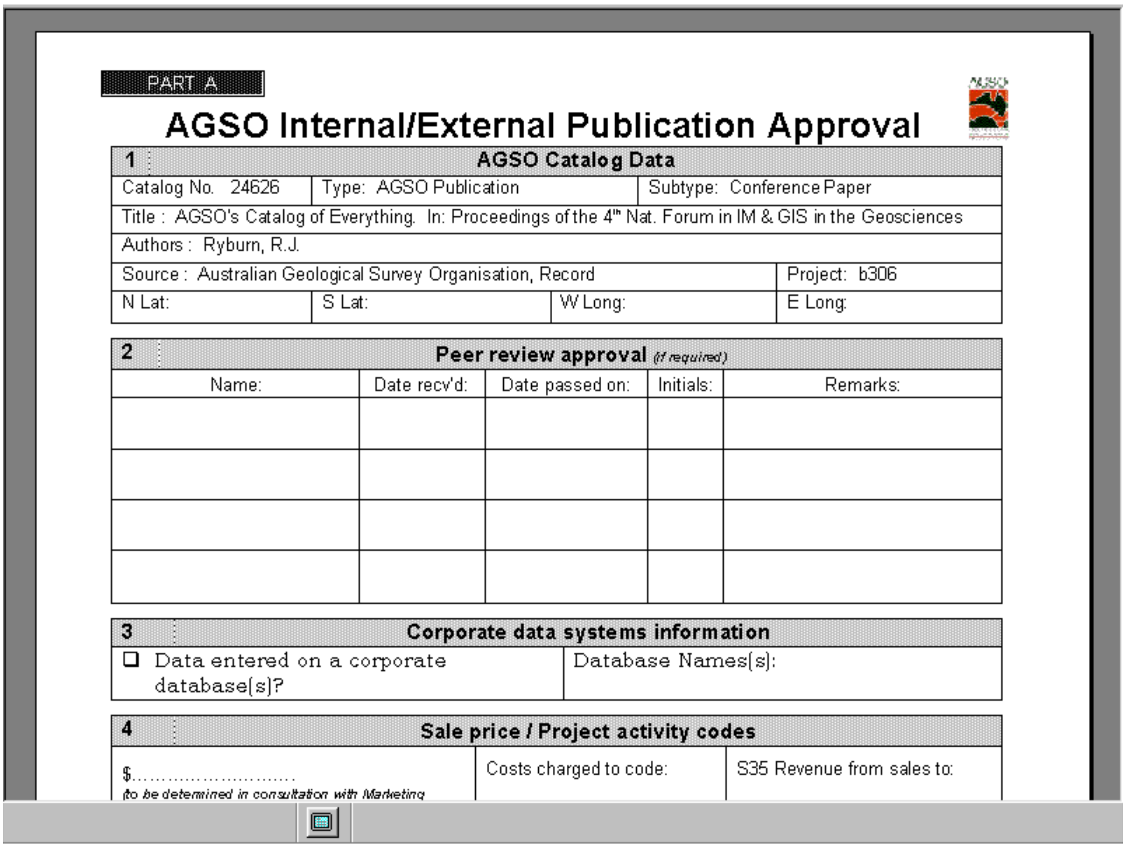


Figure 5. A table-relationship diagram of the GEOMET ANZLIC-compliant meta-database, showing the link to the AGSOCAT table. Symbols as for Fig. 2.

Publications and articles

By obtaining metadata directly from authors we hope to net entries for all external publications, papers and articles by AGSO staff, as well as entries for AGSO publications. The abstracts of publications and articles are easily inserted into the Catalog, as this is just a matter of copying the abstract from a wordprocessing document and pasting it into the appropriate field in the Catalog Initiator's Form. In some cases a pathname to a PDF (Portable Document Format) file containing the full paper or article can be inserted into the DOCUMENTS table of the Catalog, for on-demand display on AGSO's Web site. A Web interface, separate to the products query and order system, will be provided for all AGSO papers, articles and publications. The Web reports will include buttons for downloading any PDF documents that have been attached to Catalog records. Web access to documents pre-supposes that all commercial and copyright issues have first been addressed.

The carrot in this is that references to all papers and publications by an author will be visible on the Web. The stick is that an AGSO Catalog entry is a necessary pre-requisite to obtaining permission to publish from AGSO's divisional chiefs, or the Executive Director. The first step for an author wanting to publish is to enter a new record into the Catalog. Having entered the title, authorship, type of publication, target journal, bounding rectangle, etc., the author then clicks on a button to obtain a PDF file of AGSO's standard 'Permission to Publish' form, but with all the Catalog details printed at the top (Fig. 6). The author then goes through the normal peer-review processes and other formalities required to publish. Without an adequate Catalog record, however, permission to publish will not be given. Most internal AGSO publications also require ISSN or ISBN numbers, which are inserted into the Catalog by the AGSO library before the Catalog entry is processed by the Sales Centre.



PART A

AGSO Internal/External Publication Approval

1 AGSO Catalog Data		
Catalog No. 24626	Type: AGSO Publication	Subtype: Conference Paper
Title : AGSO's Catalog of Everything. In: Proceedings of the 4th Nat. Forum in IM & GIS in the Geosciences		
Authors : Ryburn, R.J.		
Source : Australian Geological Survey Organisation, Record		Project: b306

N Lat:	S Lat:	W Long:	E Long:

2 Peer review approval *(if required)*

Name:	Date recv'd:	Date passed on:	Initials:	Remarks:

3 Corporate data systems information	
☐ Data entered on a corporate database(s)?	Database Names(s):

4 Sale price / Project activity codes		
$........................... *(to be determined in consultation with Marketing*	Costs charged to code:	S35 Revenue from sales to:

Figure 6. Part of the publication approval form (prototype) that is generated as a PDF file by pressing a button near the lower-right of the Initiator's Form in Fig. 3.

Online publishing

By providing standard methods of storing and cataloguing PDF documents the AGSO Catalog opens up the possibility of setting up a formal online publishing system. For example, the "AGSO Journal", which has now merged with the "Australian Journal of Earth Sciences", could be resurrected in the future as an online journal, with good security of published material. This is an important point, because we must not permit published papers to be altered in retrospect. We cannot have geoscientists changing the contents of papers that have already been published!

When AGSO upgrades to Oracle version 8i in about a year we will be able to store PDF files inside the database in such a way that they can be seen but not deleted or changed (except by the Oracle system administrator). We will then be able to set up a new Catalog sub-type, perhaps called 'AGSO Journal Papers', and a Web interface that will present the journal papers according to the journal volume and number. The 'AGSO Research Newsletter' and 'AUSGEO News' could be similarly handled. By placing the PDF files for published documents inside the database, we can be sure that they are treated according to the established corporate backup procedures and disaster recovery plans. Such electronically published material should be kept very securely and permanently.

Downstream metadatabases

In designing the AGSO Catalog it became apparent that the one metadatabase could not encompass the organisation's entire metadata requirements. To have attempted to do so would have resulted in a system weighed down with numerous specialised data structures and fields. That would have rendered it unsuitable for general use. Instead, provision has been made for linking Catalog entries to rows in other Oracle tables (Fig. 2), and the Web interface will include a mechanism for viewing some of the data in these tables.

Examples of downstream metadatabases that will be linked to the AGSO Catalog include the REMOS database of remote sensing and processed images, and the SIMS Catalog. REMOS includes metadata on AGSO's satellite images, airborne remote sensing, other geophysical images and image-processed combinations of all sorts. The SIMS Catalog keeps track of work done by AGSO's Spatial Information and Mapping Services (SIMS) group, including maps, diagrams, charts, photographs, 35mm slides, etc. Not all of the entries in these systems will necessarily be linked to the AGSO Catalog. Judicious selections will be made and the equivalent AGSO Catalog records created by automated means in the Oracle SQL environment.

The link to downstream metadatabases makes use of two fields in the AGSOCAT table (Fig. 2). The field called 'Ora_Object' is for the name of another Oracle table or view, while the field called 'Ora_Row_ID' is for a pointer to a row in that table. Thus the mechanism for linking to other metadatabases is completely generic — to be used with any visible Oracle table or view.

Electronic mail and document registries

Plans for the AGSO Catalog do not encompass email and business registries, as that function is already handled by well-developed software systems such as IBM's 'TRIM'. AGSO currently uses TRIM, but only as a localised directory to the still paper-based file registry. The next step is to throw open the electronic registry to all staff members for the filing of important email messages and attached documents. Incoming paper mail and documents can also be scanned into the system. That might sound like a recipe for disaster, but the system includes frequent (e.g., every half hour) semi-automated checks for metadata quality. Badly filed material is thus quickly identified and the perpetrators are metaphorically wrapped over the knuckles. IBM is currently developing a Web/intranet interface for TRIM, which should make its distribution to all staff much cheaper. Along with other government organisations, AGSO will probably be forced by cost and efficiency considerations to democratise its mail registry in just a few years.

A few organisations — e.g., the National Library of Australia — have already implemented such ambitious systems across the organisation. They report a high degree of acceptance once the initial learning phase has passed, particularly amongst more junior staff members. Organisation-wide introduction of an electronic filing system such as TRIM requires the full support of senior management, a project management approach, and extensive staff training. If well implemented, the rewards are considerable productivity gains for the organisation as a whole. The alternative is to persist with insecure paper-based archives in an increasingly electronic world.

Although an electronic registry system would be independent from the AGSO Catalog, it is capable of being integrated with the Catalog, at least to some extent. Large installations of TRIM require the services of an industrial-strength database management system, and AGSO already has plans to marry its existing TRIM software to an Oracle ‘backend’. If needed, this will allow access to TRIM documents from within the AGSO Catalog, and *vice versa*.

Outsourcing blues

Following the recent transfer of AGSO from the old Department of Primary Industry and Energy to the Department of Industry Science and Resources, a decision has been taken to outsource AGSO’s financial system. The AGSO Sales Centre will probably use Web-based interfaces to the appropriate modules for issuing invoices and tracking stock in the outsourced Oracle Financials system. Similarly, the marketing group will probably use the appropriate module in the outsourced software for AGSO’s client database (currently in BookSCAN) and the maintenance of AGSO’s client mailing lists. Prior to that decision, two inhouse Oracle modules had be designed for the sales system and client database, including all the appropriate links to the AGSO Catalog. These were to replace the BookSCAN point-of-sale system.

An unfortunate consequence of the decision to outsource Oracle Financials is that it now becomes difficult to integrate the AGSO Catalog with the information in the outsourced financial system. The financial system needs the Catalog Number and some Catalog metadata for all products, while the Catalog needs the price, sales tax and availability of products from the financial system. Because the financial system and Catalog will be separated by two firewalls, automated methods of exchanging information, that would normally be easy to build between two Oracle-based systems, may be difficult and expensive to implement. In all probability the AGSO Sales Centre will have to put up with some double entry of data for quite some time to come. It may also take time for the Sales Centre to be set up and trained in the new system. In the meantime, the existing BookSCAN system will have to remain in use.

This dysfunction between the Catalog and the financial system will almost certainly mean that the two systems become unsynchronised. Deletes and updates that inevitably take place in both systems need to be religiously copied between the two systems to prevent this happening. However, if a disagreement develops between the two systems it is the Catalog that will carry the authority. After all, it is the Catalog the customer will see and the customer is always right!

Future developments

One aspect of the Catalog that will probably be developed over the next year or two is the addition of technology that allows files and other electronic objects to be accessed via a unique reference — regardless of their physical location on the AGSO network. There are currently a number of competing technologies that claim to address this issue. CORBA, which stands for Common Object Request Broker Architecture, is an open-standards system. Microsoft’s offering in this field, known as DCOM, is used by the IBM TRIM registry system discussed above. ‘Enterprise Java Beans’ is another similar system developed for the Java programming environment. These schemes are analogous to the World Wide Web’s URL system for addressing Web sites, and in theory can be used to locate an object anywhere on the Internet system. Until one such system is adopted, however, the AGSO Catalog will have to store file pathnames in the CATFILES tables. These will eventually be replaced by object references.

In the meantime, Oracle have come up with their own Internet Filing System (IFS), which stores files within the database environment, but makes them accessible from anywhere on the network. On a typical user's PC, such files can be seen as belonging to the 'O' drive, for example. IFS is part of Oracle version 8i, which is optimised for use with electronic commerce on the intranet, Internet and World Wide Web. Most of the files attached to the Catalog will probably end up inside the Oracle database environment. The UNIX and NT filing systems cannot hope to compete when it comes to corporate data security, access control, disaster recovery and flexibility, and it is considerations such as these that will inevitably win the day.

In addition, the location of all files and information inside the corporate database management system makes the job of distributing information via the Internet much easier than from UNIX or NT filing systems. Access to information becomes much more transparent , and dynamic HTML pages are much more easily created that from a filing system. Different systems become much more easily linked together.

The Catalog is seen as the key to AGSO's future systems of information distribution, both internal and external. Without an adequate centralised metadata system our efforts to access and distribute the organisation's information are likely to be dissipated into a number of overlapping but isolated systems that cost far more to set up, maintain and develop further. With a centralised Catalog we can provide generic mechanisms that should satisfy at least 80% of AGSO's requirements. The remaining 20% can be funded and developed as priorities dictate.

Acknowledgments

Developing the AGSO Catalog is team effort, with significant contributions from Ian O'Donnell (OIC SIMS), Anne Franklin, (Chief Librarian), Charlie Modrak (Marketing), Jonathon Root (Web Manager) and Oracle forms and reports development by Stuart Ross.

This paper has benefited greatly from peer reviews by Jonathon Root, Ian O'Donnell, Anne Franklin and Sonja Lenz.

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GIS and data management …. 2 years on: BHP World Minerals, Discovery Group

Lili Haas
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BHP World Minerals, Discovery Group

2 years ago ….

Two years ago the challenges that we faced were related to making the GIS environment 'Geo-friendly'. Essentially, the core issue was data management – developing and implementing standards, and putting into place structures that would make finding relevant data easy for the Geoscientists. The topics covered were the implementation of:

- Standard directory structures
- Standard coverage and image naming conventions
- Read, write, and edit protection for our master datasets
- Metadata

Having put these basic principles in place, our next focus was adding geological value to the data in terms of:

- Expanding codes (providing information)
- Concatenation of coverages (fewer to manage)
- Concatenation of attributes (better querying)
- Adding fields (from reports and maps)
- Adding value through the process of Union

As our region has broadened, to include some Asian offices, the challenge has been to ensure that these same standards and principles have been adopted at these sites. Geoscientists working in these offices, and familiar with the Australian GIS environment, have commented that locating relevant information has been made easy by the adoption of the same standards, particularly directory structures.

Finding relevant information, especially when you have over 6000 coverages at some sites, is not a trivial task. With the implementation of standard directory structures and a sophisticated metadata system, Geoscientists have several search options:

- Browse the relevant directories (differentiated by area and data type)
- Search the Metadata Catalogue by keyword (text query)
- Search the Metadata Catalogue by selecting an area of interest (spatial query)
- Combined keyword and spatial search of the Metadata coverage

With these fundamental procedures and principles in place, we have been able to provide a consistent one-stop GIS environment, which has been readily understood by even the most casual user. The key fundamentals were, and still are:

- Consistency, consistency, consistency
- Standards, standards, standards

The focus over the last two years has been GIS analysis - using the data not just collecting and managing it. Finally, the real value of GIS is being realised.

GIS analysis

GIS has changed the way our Geoscientists work. The data, that was once buried in hard to use Oracle databases requiring specialist skills to extract or query, is now available through the GIS interface. We have ensured that all spatial data is available via GIS. Geoscientists, along with technical support, drafting and tenements staff, use GIS on a daily basis. It is one of the key exploration tools, particularly for project generation.

Numerous prospectivity mapping and regional analyses have been undertaken using the functionality of GIS. This work is becoming more sophisticated as the breadth and functionality of GIS is realised, and routines are being automated to test ideas using available data. Both data-driven and model-driven analyses have been undertaken. Our extensive geochem database, with over 1.8 million samples, has been processed and exhaustively analysed through GIS – a task that would have been extremely difficult to undertake not long ago.

This enthusiasm for GIS analysis has been predicated on the fundamentals (described above) which have now been established for several years, and have proven to be more that adequate for our Geoscientists (sustained through time without the need for change).

The extensive use of GIS for analysis has however, highlighted two major problems with digital data from data suppliers:

1. The lack of robust quality control checks on data, particularly geochem data.

2. The data is not focused or customised for the end-user, particularly the GIS end-user (eg. mining industry clients such as BHP) who are trying to realise value out of digital data through GIS analysis.

It has become evident that many data suppliers (state government surveys and third party data collectors and distributors) have not been as rigorous as we would have expected in the collection of geochem data. The dilemma of garbage in - garbage out (GIGO) persists. We have had to run extensive QC checks over all our geochem data, and in some instances have returned the data to the supplier for correction. The typical problems encountered for geochem and other digital data have been:

- Geochem data within the column and the headings do not match
- Geochem inconsistencies between the level of detection, BLD values and results

- Geochem and geology data from adjacent mapsheets contain completely different sets of attributes, even though they are part of the same mapping program.
- Perception that if it has been supplied digitally that real progress has been made - wrong. In our opinion a digital product is not useable and its value is not realised until it has been attributed with GIS analysis in mind, and this means adopting standards.

These problems indicate that data suppliers are grappling with basic digital data management practices; there are no apparent corporate geochem databases in some instances; no corporate coordinators enforcing minimum standards; and data is being collected digitally with no thought to GIS analysis and how it might be used. These are pretty harsh accusations, but they are based on our experience.

One of the simplest ways of doing a quick QC check on data is to take it into GIS, and by colouring unique values in each field and sorting each numeric and text field (ascending and descending), the typographic errors and the outliers in the data can be quickly identified. But data suppliers have not employed even this rudimentary approach.

Transcribing data from data supplier formats into corporate systems with the necessary checks and balances requires an enormous amount of effort. If this is then burdened with the need to conduct basic QA/QC checks and corrections that the data supplier should have performed, it is a waste of our diminishing resources and a data-handling inefficiency that we can do without. Management are reinforcing this message and indicating that "it is not our job to fix poor quality data from data suppliers - send it back – we don't want to pay for poor data, it is the responsibility of the data supplier to ensure that it has been rigorously quality control checked." This is the new reality.

It is pretty clear what our needs and expectations are. We need:

- Geochemical data that has been validated and checked for errors.
- Digital point/line/polygon data that is attributed with GIS analysis in mind – smart digital data not just cartographic products with cryptic codes attached.

Exploration industry changing – the future

In Australia the large exploration companies are fast disappearing. Companies are under extreme pressure to down size as a result of low commodity prices and decreasing budgets. The pressure is on to do more, faster, better, with fewer resources in order to become more responsive, competitive, and aggressive.

Exploration groups are being forced to re-define their businesses, in particular re-evaluate their core competencies. A different culture is emerging and non-core functions will increasingly be outsourced.

Companies, like BHP Minerals Discovery, can no longer afford to provide a full set of in-house services and self-maintained databases. We are increasingly focusing on those activities that are core and create value for the organisation and are considering outsourcing parts of those functions deemed to be non-core. Many of the following functions have already been affected:

- Development of in-house applications (buy off the shelf generic applications)
- Help desk service for software applications
- Other technology support such as Email
- Computing and drafting groups
- Data Administration – digitising, reformatting and correcting data from data suppliers
- Landsat processing and management
- Geophysical data collection, processing and management
- Field logistics, including drill program supervision

The minerals industry is going through a cycle of change - major change. After the initial shock has worn off, companies will take stock and re-think existing ways of managing (data) and look for new ventures and opportunities.

What does this mean for GIS and data management?

The number and types of service companies will increase. Data bureaus might evolve to manage the data from a number of clients – to format, edit, perform quality control checks and negotiate with data suppliers. They might become data warehouses and data brokers for clients and/or industry, facilitating data sales and exchanges between companies. This is already happening in some quarters of the minerals industry and has been happening in the petroleum industry for quite some time. We (the minerals industry) are catching up.

What data suppliers need to do the meet the challenge

It is naïve to think that government agencies can continue to do what they have been doing. The demand for high quality data and the deployment of standards will be a priority issue, regardless of who will be managing the data.

I would encourage data suppliers to consider very carefully the following:

- Nominate a corporate GIS/Data Coordinator to set the standards for digital data capture and delivery
- Implementation of corporate databases to provide a consistent product
- Employ more rigorous QA/QC procedures and practices
- Understand your Customer / Industry – canvas their needs and ideas
- Develop a set of industry standards for data in collaboration with industry – liaise with other state Mine’s Departments rather than employing self-serving practices

Two years ago I concluded by saying that if we want quality decisions from GIS then we need quality data, and that there was room for improvement for data suppliers to be more rigorous in their quality control checks and planning of attributes for the end-user. Two years on … there is a lot more digital data available but there is still room for improvement.

Decentralised GIS—an M.I.M. perspective

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Abstract

Over the last six years M.I.M. Exploration (MIMEX) has focused on developing a spatial data management system that enables the visualisation and analysis of data at the area of operation. It allows up-to-date information to be in the hands of the decision makers around the world. This has been a major turn around and re-think from the days of centralised data management.

This paper highlights some of the advantages and disadvantages of decentralised GIS from a M.I.M. (Mount Isa Mines) perspective and what the future holds. We are living in exciting times of constant change, which require our systems to be adaptable to all conditions and environments. The challenge of the 21st Century is to harness technology to work for us and not against us, enabling us to work more efficiently and effectively, without impacting on our overall lifestyle.

Introduction

MIMEX entered the GIS world in early 1992, when it started looking at MapInfo[1] as a tool for mineral exploration. This began in Mount Isa on a small scale trial. In early 1993, MIMEX moved to Brisbane and an R & D (Research and Development) project was established to develop a GIS and examine the benefits of using GIS in mineral exploration in the Mount Isa Inlier. As part of the R & D project, MIMEX employed a GIS specialist. After the early trial in 1992, MIMEX had decided that MapInfo was not capable of providing what was required and that Arc/Info[2] would be better suited to the job; however, popular demand over the last few years has turned the focus back to MapInfo.

Discussion

In early 1993 the aim was to design and implement a centralised GIS to aid exploration efforts in the Mount Isa Inlier (Figure 1). As can be seen from Figure 1, the centralised GIS was located in the Brisbane office, 1600 km from the study area. In terms of hardware, a Sun SPARC10 (64 Mb RAM and 4 Gb disk space) and a Hewlett Packard Xterminal were purchased. Peripheral equipment included SumaGraphics A0 digitizer, Hewlett Packard Draftmaster pen plotter, and Hewlett Packard XL300 inkjet plotter (Figure 2). The software was a three node locked license of UNIX Arc/Info, one license of Grid, and one license of TIN. The total equipment and software startup cost was approximately A$80,000.

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[1] MapInfo is the registered trade mark of MapInfo Corporation, New York, USA.
[2] Arc/Info, ArcView and ESRI are registered trade marks of Environmental Systems Research Institute, Redlands, USA.

During late 1993 and 1994, major resources were spent acquiring and generating digital data for the study area. Once sufficient digital information was available, the focus changed to developing user-friendly front ends to the GIS to make it easy for explorationists to access information and produce maps. In 1995, the Map Production System was developed which allowed explorationists to produce up-to-date tenement maps for any part of Queensland (Figure 3 and Figure 4). They could also add any other information available in the GIS (e.g. geology, roads, rivers, etc.) onto these maps at a press of a button.

During the later part of 1995 time was also spent developing analytical and spatial modelling components for the GIS (Jayawardhana and Sheard, 1997) (Figure 5). Monthly tenement change detection, competitor monitoring and target monitoring products were also made available. These techniques and products took GIS beyond a data visualisation and integration and enabled it to provide invaluable information in helping MIMEX geoscientists better understand the complex environments in which they work.

In February 1996, MIMEX reviewed progress to date and concluded that GIS was indeed a very useful tool in mineral exploration and that it's availability should be expanded. Though extremely positive in its outcome, the review brought some very difficult questions: how would we implement a centralised GIS in a company which spans the globe? How could MIMEX provide widely available GIS hardware, software and support within a restricting exploration budget? What people resources was MIMEX willing to contribute to a GIS expansion?

In answering these questions M.I.M. moved into a new phase of spatial data awareness.

The implementation plan was to use Arc/Info as the centralised GIS and have ArcView[2] at all exploration offices, worldwide. ArcView would then be the GUI (Graphic User Interface) to the GIS data and MIMEX would customise this environment to the needs of the users.

To deal with the question of cost, the plan was to keep the GIS infrastructure as simple as possible. Again ArcView on a Personal Computer (PC) platform was the ideal interface and MIMEX approached ESRI[2] for a cost effective deal to cover all operations around the world.

Although MIMEX management wanted to see GIS expand to 15 different offices around the world they were not prepared to see GIS support staff increase from one. For GIS to succeed, global operations had to rely heavily on the existing personnel and resources at each of the offices. The GIS had to also be useable and 'owned' by explorationists and not GIS experts. This also meant a comprehensive training and education program to elevate the knowledge and awareness of the value and usefulness of GIS as a mineral exploration tool.

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[2] Arc/Info, ArcView and ESRI are registered trade marks of Environmental Systems Research Institute, Redlands, USA.

In late 1996 cracks began to appear in the grand plan. The ArcView 2 release had been delayed and we were not going to see a stable and useable version of ArcView enter the market place till 1997. This was a major blow to our overall plan as everything was hinged on getting ArcView and customising it to suit the needs of our offices around the world. Faced with this delay, sites which wanted to use GIS started to purchase MapInfo as an interim solution. MapInfo had come a long way from the package that was tested in 1992.

The start of 1997 saw M.I.M. straddling two GIS software packages (Arc/Info-ArcView and MapInfo). This was a very difficult period as technical support and data management were still provided by only one individual. In mid 1997, the user-friendly nature of MapInfo had won overwhelming support from MIMEX geoscientists; MIMEX made the strategic decision to use MapInfo as its main GIS with Arc/Info-ArcView used in the background in Brisbane. This decision was a major turning point. Implementation of GIS into all of M.I.M's exploration offices began, with the aim of being completed by mid 1998.

Around the same time as MIMEX started implementation of GIS globally, GIS was introduced into M.I.M.'s environmental operations at Mount Isa Mines and the implementation of a decentralised GIS which supported all M.I.M. operations had started. GIS was evolving from a centralised system used by MIMEX to a decentralised tool used beyond just exploration, but rather, in the full circle of M.I.M.'s operations. The digital data generated at the exploration stage could be passed on and used in the production and environmental management stages of operation (Figure 6). As shown in Figure 6, this enables a two way flow of information, which would aid all aspects of M.I.M.'s operations.

The beginning of 1998 saw M.I.M.'s commitment to GIS expand to a new height. MIMEX brokered a unique global deal with MapInfo Australia enabling centralised licensing and decentralised operations. This opened the doors for the global expansion of GIS to all areas of operation (Figure 7). The new study area as shown in Figure 7, was a far cry from the original shown in Figure 1. Decentralised GIS was now expanding to 11 exploration offices and 9 environmental offices around the world. Implementation of GIS into M.I.M.'s environmental offices started in early 1998, with the aim of being completed by the end of 1998.

M.I.M.'s approach to GIS has been unique in two ways. The first is that it is one of the few mining companies in the World that is using GIS throughout the full range of its operations (Table 1). This has enormous benefits in terms of data management, cost savings and better utilisation of the available information. In 1996/97 MIMEX spent approximately fifteen million dollars on capturing and acquiring digital data. If at least one percent of this data was passed down the line to development and environment this would, equate to a cost saving of one hundred and fifty thousand dollars to the M.I.M. group. GIS has also provided a uniform data format for transfer of digital spatial data throughout the M.I.M. group. The second, is that at present M.I.M. has not allocated people to manage and support the decentralised GIS at each site, and this is an area which will need attention in the future.

Even with limited personnel, implementation of GIS into M.I.M.'s exploration offices was completed ahead of schedule. An ongoing education and training program is underway to develop in-house GIS expertise at each office by the end of 1999.

As we rocket forward into the 21st Century, there are many challenges that lie ahead. One of the greatest challenges confronting GIS is the ability to integrate information from different packages and applications (Figure 8). At present M.I.M. is working towards making all of its applications software compatible with GIS. The aim is to be able to feed information into the GIS from the plethora of in-house and off-the-shelf applications packages. This is progressing very well at present with a number of strategic alliances already being forged with a number of applications developers to ensure that geophysical, geological and geochemical information can be passed directly to the GIS from the generic applications software. Two areas where M.I.M. is looking to improving integration is in orebody modelling (Figure 9) and geophysical modelling (Figure 10).

New technologies in satellite telephony and worldwide differential Global Positioning Systems (GPS) are revolutionising the way we work. We can collect information to a positional accuracy of $\mp$5m anywhere in the world and have this information emailed via satellite phone to any office in the world from the field. New geophysical techniques and equipment are allowing us to look for minerals at greater depths and enabling us to re-explore old mining areas with greater effectiveness.

Paralleling the development and implementation of GIS throughout M.I.M. has been an education program to highlight the importance and value of digital data. MIMEX has recognised that it spends millions of dollars on capturing digital data and very little (<1%) on cataloguing, archiving and preserving these datasets for future use. This trend is slowly changing with the introduction of a Spatial Data Management System at all MIMEX offices and a centralised Archive and Spatial Data Index. The Spatial Data Management System is a directory tree structure developed at the base level. Each MIMEX office around the world follows the same general structure and only minor modifications are necessary depending on the application packages used at the base. The Archive and Spatial Data Index is a system to copy and archive all digital data purchased, acquired and captured by MIMEX throughout the world. The overall index is written to CD every six months and circulated to all Exploration offices. The metadata associated with each dataset is recorded and made available through a GIS interface and database interface. The Spatial Data Management System and Archive and Spatial Data Index work hand in hand with GIS. These two systems are fundamental to the management and accessibility of MIMEX's extensive digital data archive containing more than 11 Terrabytes of data.

Conclusions

Over the last five years M.I.M. has switched from Arc/Info-ArcView to MapInfo and changed its focus from a centralised GIS to a decentralised GIS. Both these decisions have been driven by the needs of the users. This willingness to listen to the users has placed M.I.M. in a unique and united position in regards to GIS development and utilisation.

As M.I.M. moves into the future the two keys to successful application of GIS software will be integration and data management. At present half of the applications packages used by MIMEX can be integrated directly into GIS. In the future all applications packages will provide information to the GIS.

Data management is slowly being elevated from a behind the scenes requirement to a very important aspect of our day-to-day work. Without access to the best quality data and the metadata associated with this information, explorationists can make ill informed decisions with expensive consequences. Surprisingly enough, data management has received the least support in the past. In today’s digital world it is imperative we rectify this shortsightedness as the increasing volumes of digital data collected today, if not managed at the point of capture, will be impossible to find as time goes on.

References

Jayawardhana, P.M., and Sheard, S.N., (1997). The Use of Airborne Gamma Ray Spectrometry by M.I.M. Exploration - A case study from the Mount Isa Inlier, North West Queensland, Australia. In: Proceedings of Exploration 1997 - Geophysics and Geochemistry at the Millenium - the Fourth Decennial International Conference on Mineral Exploration. Prospectors and Developers Association of Canada.

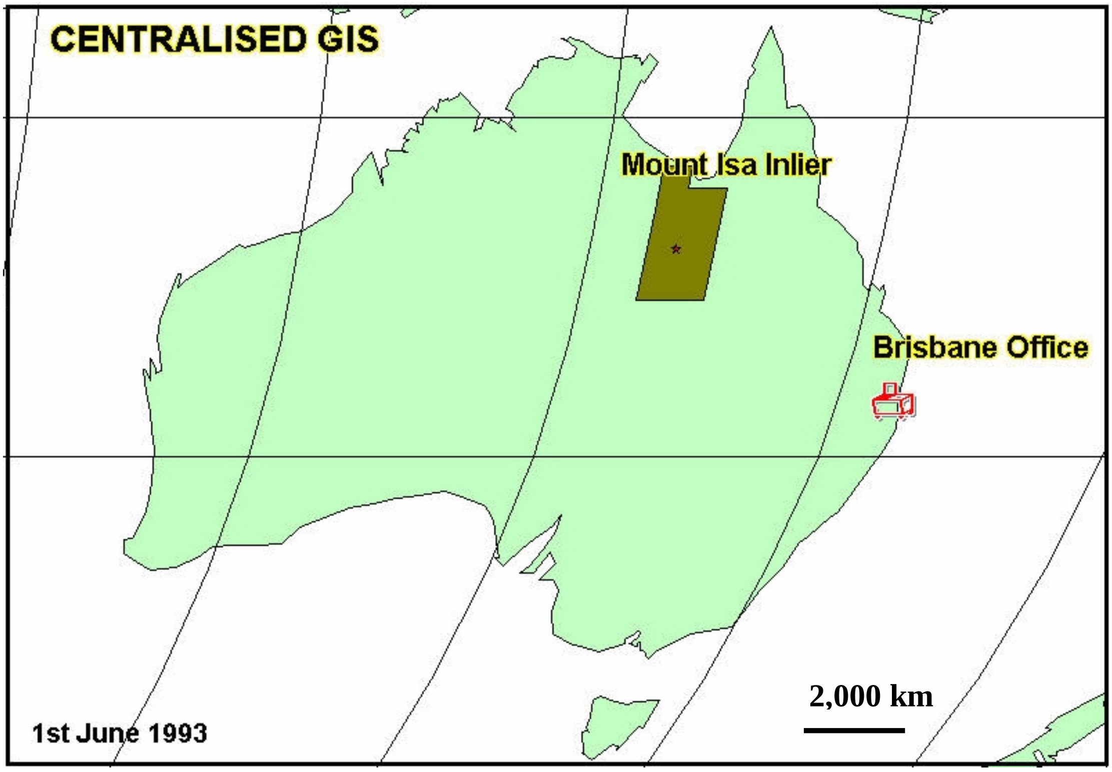


Figure 1. GIS study area in 1993 (centralised GIS).

Figure 2. Collage of the GIS infrastructure.

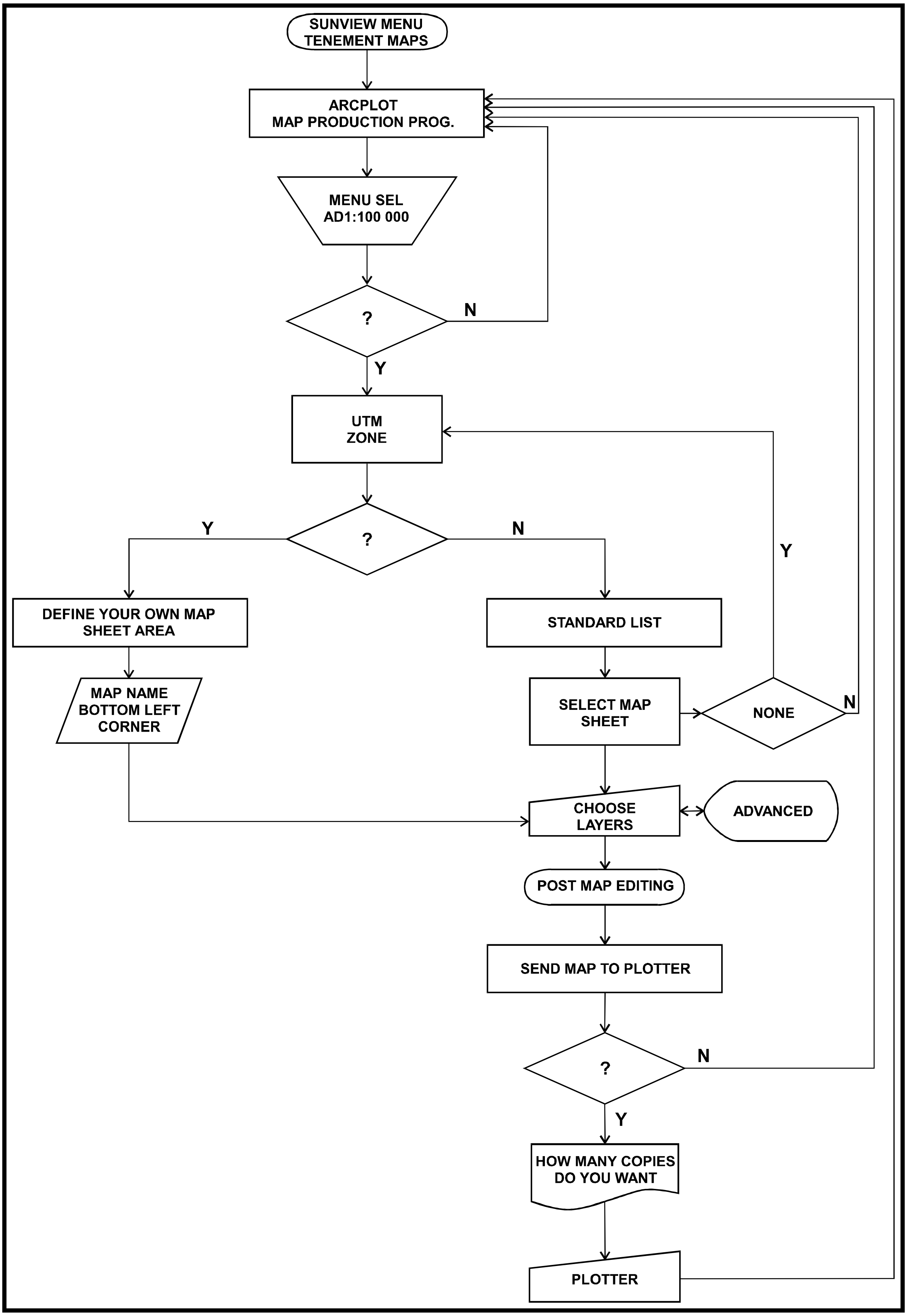


Figure 3. Map Production System flow diagram.

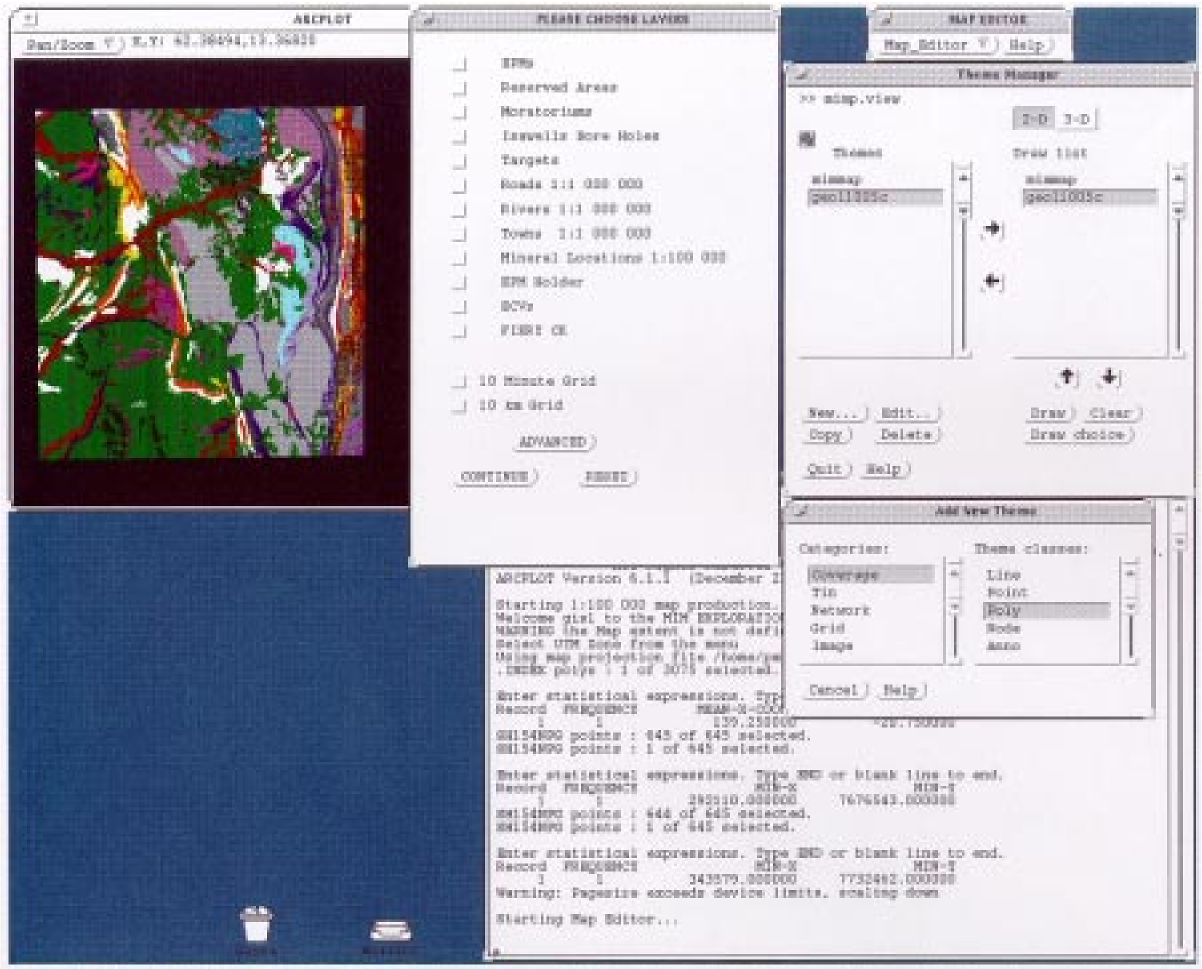


Figure 4. Map Production System screen shot.

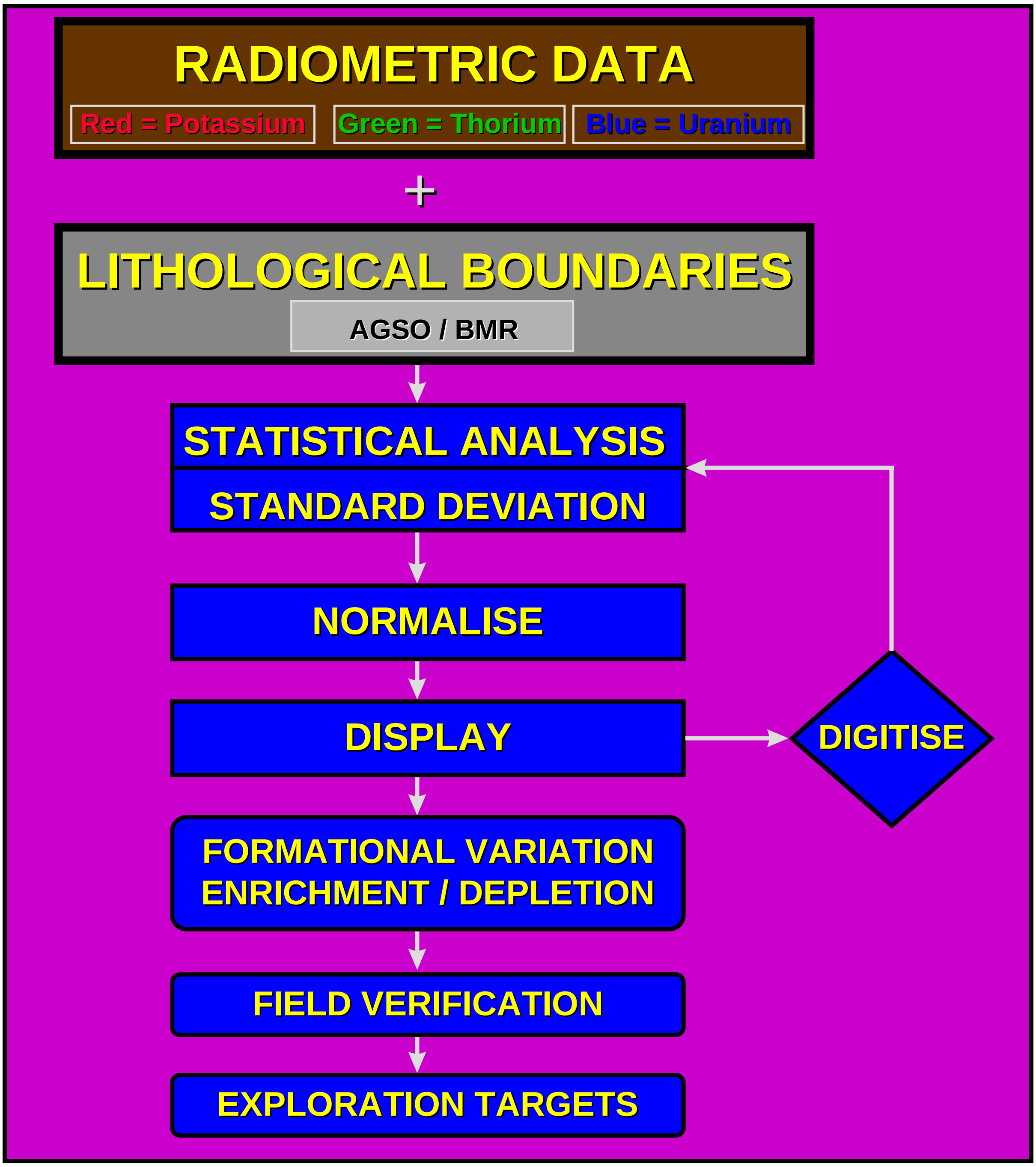


Figure 5. Flow chart of spatial modelling procedure using GIS.

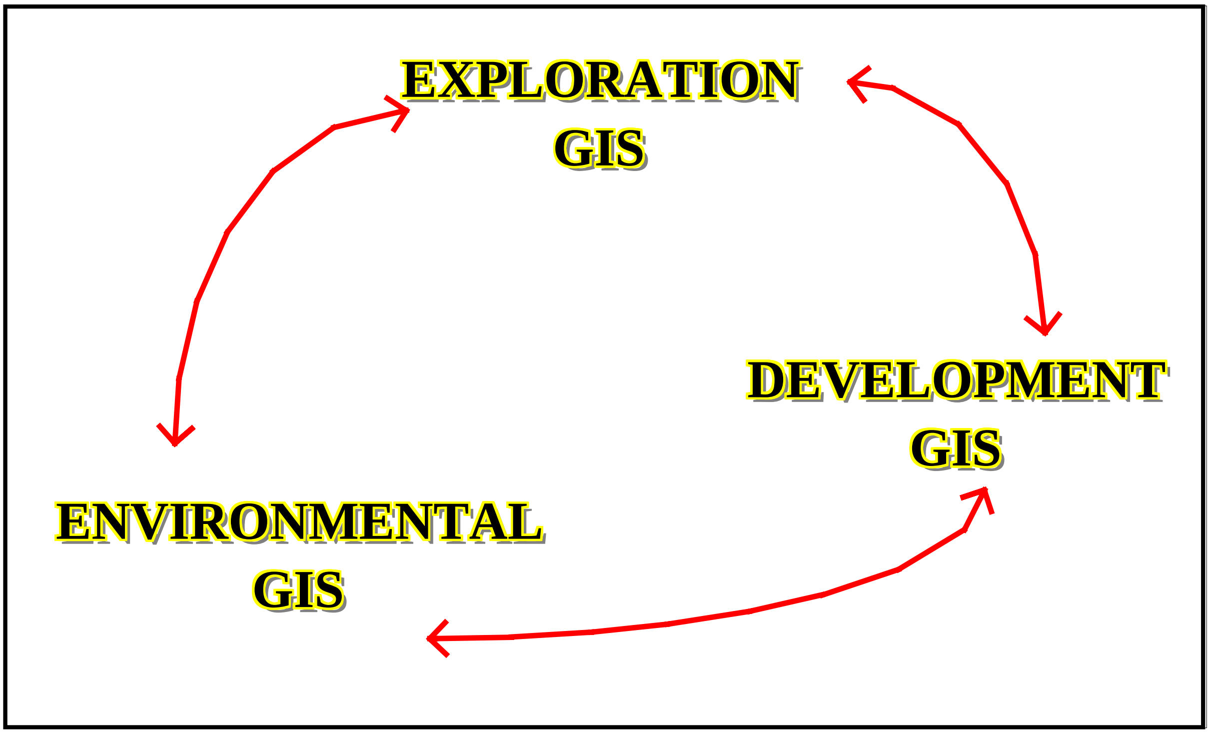


Figure 6. M.I.M.'s GIS strategy.

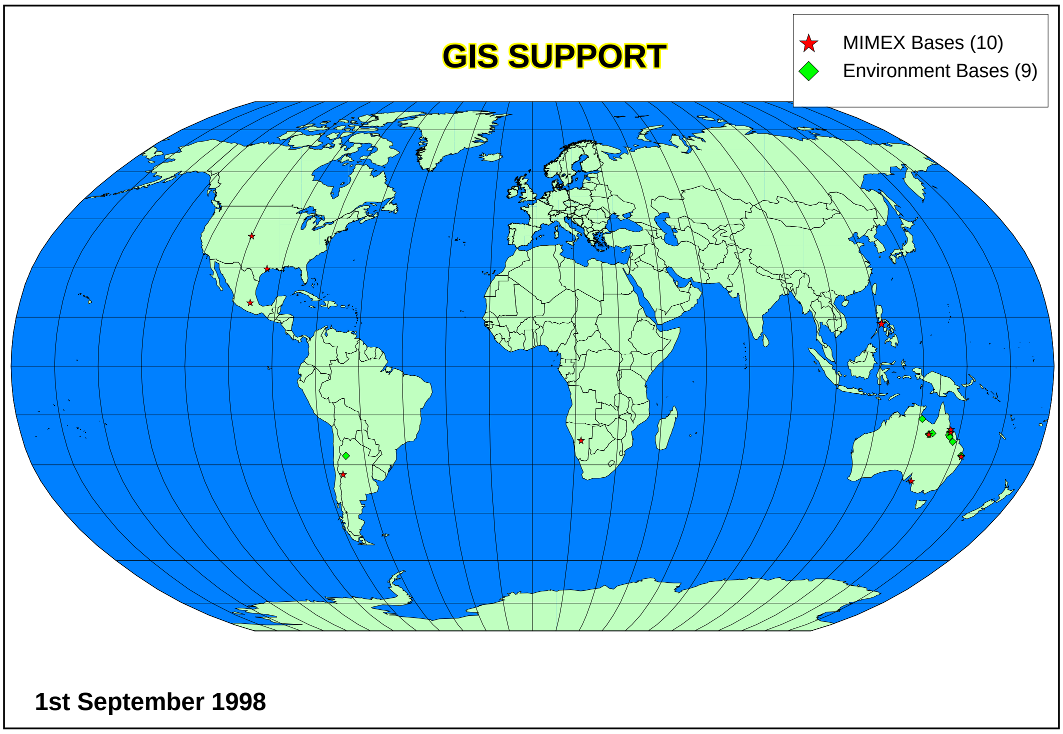


Figure 7. GIS study area in 1998 (Decentralised GIS).

Table 1. GIS in the mining industry.

Company	Exploration Budget ($M)	GIS in Exploration	GIS in Development	GIS in Environment	GIS data flow
Anglo-American	NA	✔	✕	✕	✕
BHP	90	✔	Some	Some	✕
MIM	22	✔	✔	✔	✔
North	50	✔	✕	Some	✕
Pasminco	17	✔	Some	Some	✕
Placer	86	✔	✕	Some	✕
RTZ	120	✔	Some	✕	✕
WMC	50	✔	✕	Some	✕

(Industry sources, June 1998).

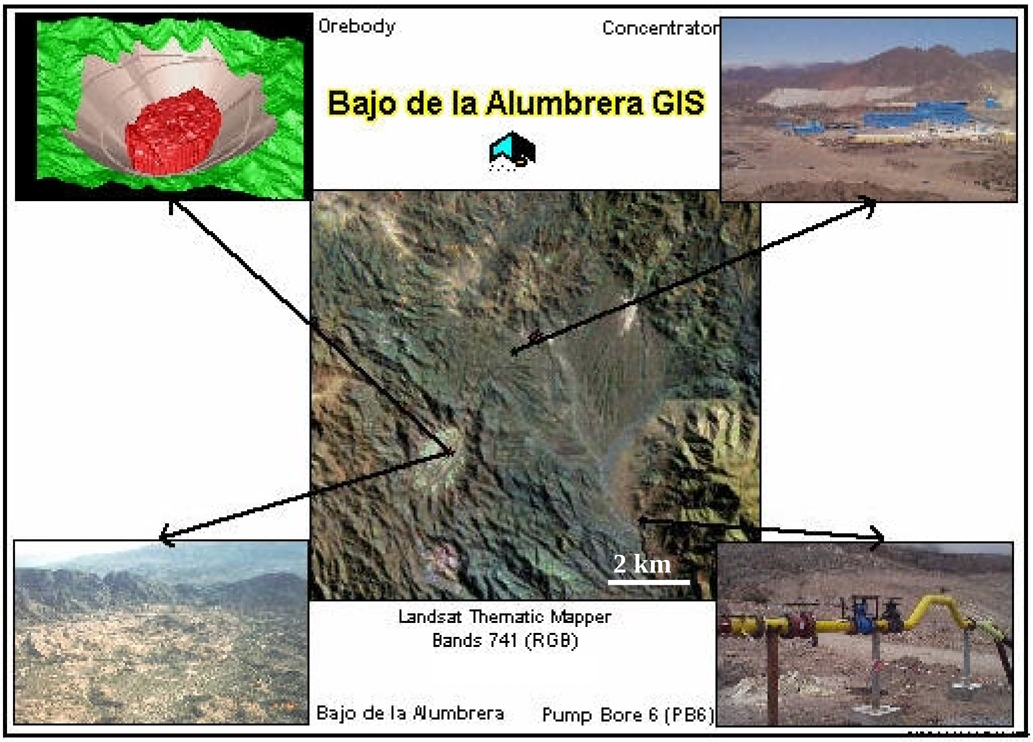


Figure 8. Using GIS for data integration.

Figure 9. Orebody modelling.

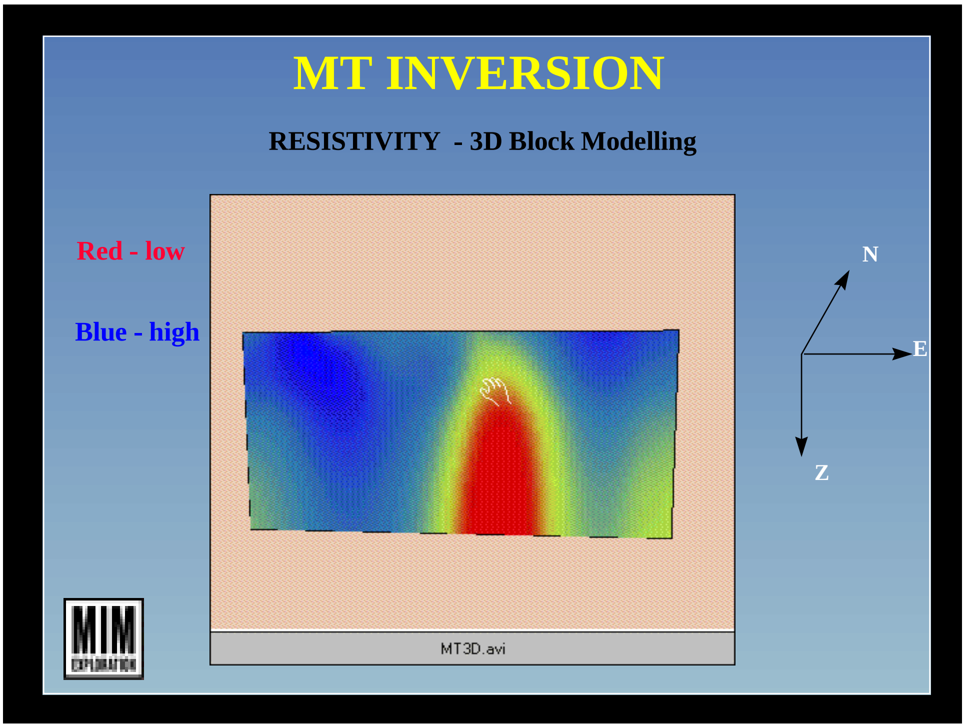
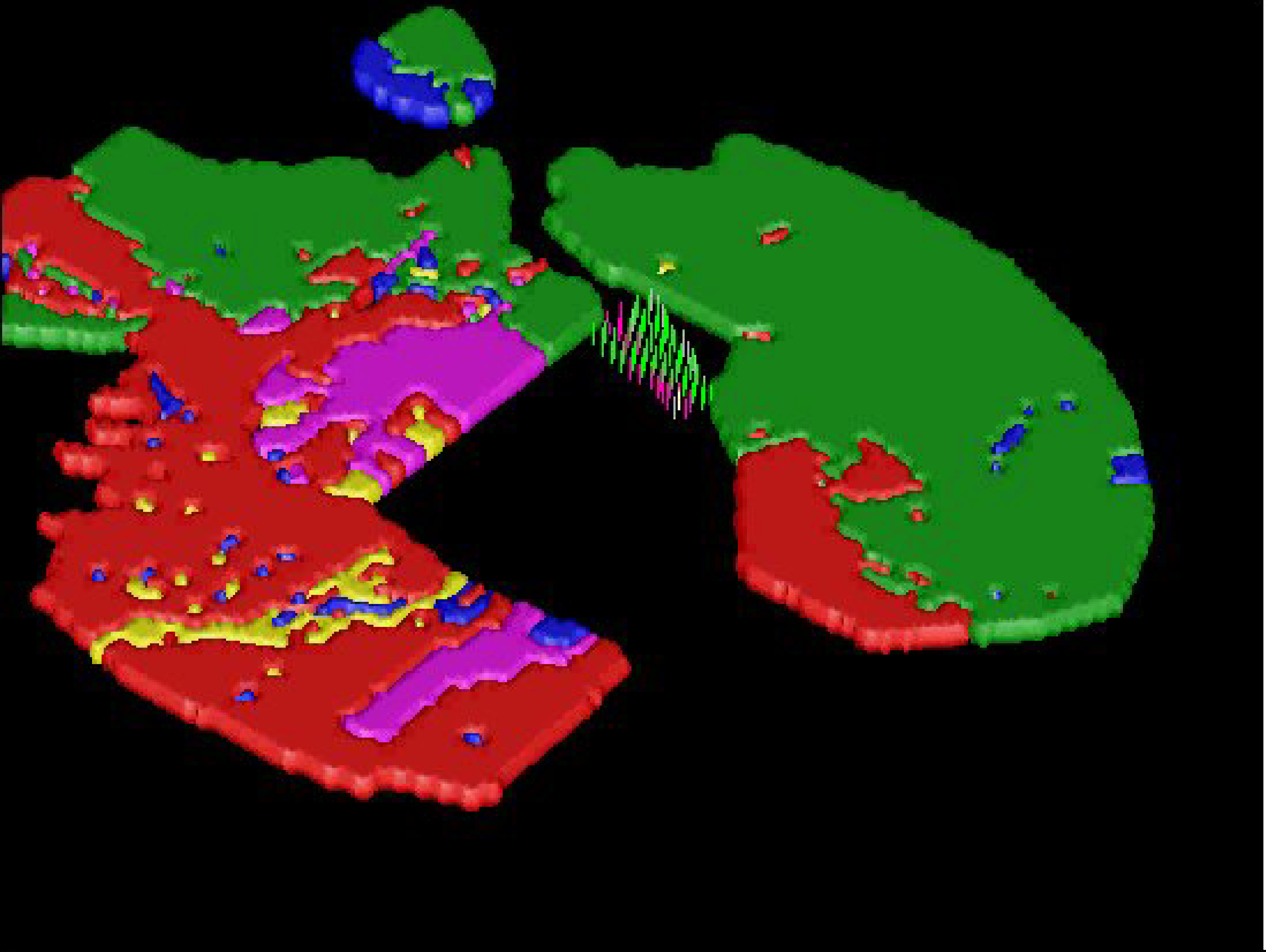


Figure 10. Geophysical modelling.



Orecontrol

Analysing digital data sets on a national scale—what are the essentials?

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Abstract

As the national Geological Survey, AGSO has a major role in creating unified national scale digital data sets to enable continent-wide analysis of geoscientific data and information. However, unifying disparate data sets into national-scale digital coverages has revealed many pitfalls that to date have not been apparent in the more common regional-scale digital compilations. It is unfortunate that in moving to the digital age, many of the vital standards that existed in the paper world and that had painstakingly been built up over many tens of years of producing national-scale hard copy maps and reports have been forsaken.

Recently AGSO completed 2 national scale projects – National Digital Data Sets and the Proterozoic Granites Project. For both these projects it is clear that there are five essentials in creating unified national digital data sets:

1) The original digital data capture must be of the highest quality possible;
2) National data standards are required to not only allow rapid, accurate and efficient transfer of existing digital data between geoscience and other relevant organisations, but also to enable rapid compilation of regional- to district-scale data sets into unified national-scale coverages;
3) Within any long term project, a high degree of discipline is required throughout the capture process to ensure consistent adherence to data standards throughout the data compilation process;
4) Long text strings must be kept to a minimum. Text data must be captured in properly structured attributes so that they are readily searchable in a GIS or database; and
5) Comprehensive metadata must be provided to ensure that the user understands precisely what data have been compiled and how it has been attributed.

Introduction

In its role as the national Geological Survey, AGSO is increasingly utilising the opportunities that modern digital information management systems offer (e.g. relational data base management systems (RDBMS), geographic information systems (GIS) and the Internet) to create national scale digital data sets that enable far greater large scale visualisation and analysis of geoscientific data than ever before. In the industry sector, new strategies for exploration also increasingly involve manipulation and integration of large digital data sets within GIS. For many years national-scale digital image data sets of gravity and magnetic data have been available. However, high quality national scale digital compilations of vector and point data have not been so forthcoming.

AGSO recently completed two national scale GIS projects, the National Digital Data Sets project and the Proterozoic Granites project. In this paper, we will outline the basic methodology that was used to compile these two national-scale projects. Both these projects highlighted several difficulties that have emerged in the new digital age, and may perhaps provide the reason as to why national scale digital data sets are not being so readily created from vector and point data sets. We will elaborate on these difficulties and make recommendations for improving the capture and storage of digital data in Australian geoscience organisations so that National scale data sets can be far more easily and eventually automatically compiled.

The National Digital Data Sets project

The National Digital Data Sets project compiled 30 data themes (including point, vector and image) as GIS coverages. Some of these data sets are primary data (e.g. geology, metamorphism, regolith) whilst others are subsets of AGSO's major national databases (*e.g.*, OZCHEM (whole-rock geochemistry), magnetics, hydrology). All data sets have a common coastline, common projection and common central meridian, so that all data sets can be easily integrated within a GIS.

However, in achieving this unified national data set major problems arose from digital data not being standardised both within and between various data suppliers. The worst example was the coastlines and in the ~15 original printed and digital source maps used, there were about five significantly different coastlines and all vector data sets had to be standardised to the Digital Chart of the World (DCW) coastline. This was not a trivial matter as there are 973 islands off the coast of Australia, and each of these islands had to be manually re-attributed for each coverage.

Descriptive geoscientific information can easily be added as structured attributes to any digital map. However, trying to effectively compile this information for coverages in the National Digital Data sets was not easy. The descriptive geoscientific data associated with most of the source printed maps were mainly available as highly abridged text strings in map legends which were rarely recorded consistently enough to provide attributes that could be used for systematic analysis. Alternatively, some information was only available as full descriptive text blocks within accompanying explanatory notes/reports. Converting these long text fields into searchable attributes within a GIS was not a simple task. An example of this was the geological regions data set, based on the 'Guide to the Geology of Australia' by Palfreyman (1984). This data set consisted of a map of Australia showing boundaries of the geological regions, with data on each of these regions tabulated into eleven categories in detailed accompanying notes. The text descriptions in most of the categories had to be abbreviated to less than 255 characters to fit within the field-length limits of some commonly used GIS applications, and hence several categories were split into several fields. In some of these text descriptions there was also no consistency, for example in the ages listed for each region, some regions were classified as an eon (*e.g.*, Archaean) and others covering several eras and periods (*e.g.*, Neoproterozoic to Cretaceous). Although perhaps permissible in a descriptive document, this age field had to be more rigorously standardised to allow effective integrated analysis within a digital system.

The digital geology map of Australia highlighted that the scale of compilation for generating paper maps probably caused the greatest restriction in the amount of data that could be presented on a map. As this map had been compiled at 1:1.25 million scale, it was only feasible to show geological units at the Group level, and hence information about the units that make up the Group were left off the map face. However, in the digital map, if the individual Groups had been coded with the Stratigraphic Index number, by joining to the Australian National Stratigraphic Index data base, information about the units that make up each of the Groups could be easily accessed (Brown et al., 1997).

On completion of the National Digital Data Set project, it was clear that there were 2 main analytical advantages. The first was the ability to use the combined data sets for purposes other than what had been the initial rationale for collecting the data. For example, Figure 1 is a coverage from ROCKCHEM showing Th and U values compiled from many individual whole-rock geochemical surveys. Collectively these data highlight areas in Australia that are potential radon hazards, as radon is released by rocks that are high in Th and U. The second advantage was the ability to integrate disparate data sources to do 'unusual' analysis. For example, Figure 2 shows earthquake epicentres including one measuring 4.5 on the Richter scale which occurred at Appin, NSW, on 17th March 1999, with aeromagnetics as a backdrop.

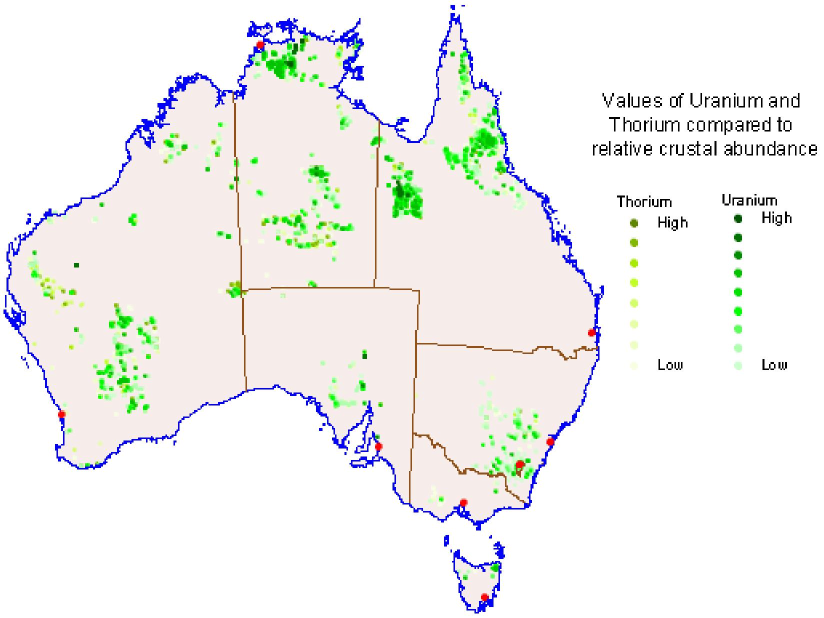

Figure 1: A subset of the ROCKCHEM data base, showing uranium and thorium values. Not only does this image show the location and relative value of the samples, it also shows areas of potential Radon hazards, as radon abundance is released by rocks that are high in uranium and thorium.

Earthquake epicentres from the Australian Seismological Centres earthquakes database

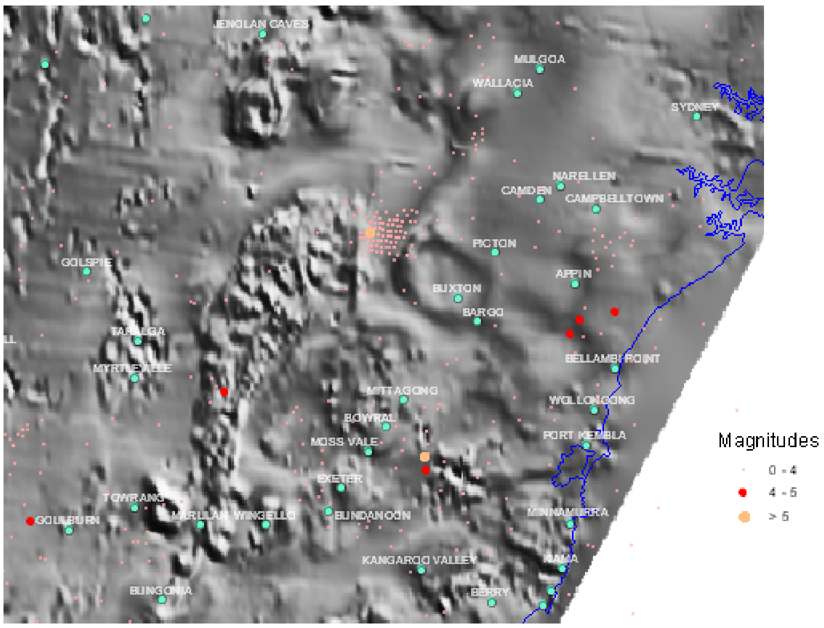

Figure 2: Image of earthquake epicentres and their magnitudes overlain on aeromagnetics. The aeromagnetics image is a part of the Australia-wide coverage of AGSO, and the earthquake data is from AGSO's EARTHQUAKE data base. This data base automatically captures data from a network of seismographs around Australia, and the data is made available on AGSO's website. In particular, this image shows how properly structured data sets can be quickly combined and used to provide up-to-date information with ease.

The Proterozoic Granites project

The Proterozoic Granites project was co-funded by 20 industry sponsors, and carried out in collaboration with the State and Territory Geological Surveys. The project sought to define the metallogenic potential for granite-related Au, Cu ± base metals in each Proterozoic province in Australia. Granite plutons were assigned to suites on the basis of geochemistry, geochronology, petrology and field relations. The petrology and field relations of the host rocks to each granite pluton were also captured, because of the recognition that granites interact chemically with their host rocks and that this then influences their ability to play a role in generating mineral deposits.

The basic data model used for the GIS was refined from two projects previously undertaken at AGSO: the Mt Isa half-million scale GIS project (Wyborn et al., 1994), and the North Queensland Felsic Igneous Rocks GIS (Champion & Mackenzie, 1994). However as the project progressed the data model had to be modified as more complex data types were encountered *than had been anticipated.*

Nearly all of the geochemical data were available digitally and mostly came from AGSO's ROCKCHEM database. The remainder came from databases from individual State and Territory Geological Surveys. As there is no national standard for storing whole-rock geochemical data, considerable time and effort was involved in massaging the data from the States and Territory into a format suitable for processing. It was found almost impossible to gain whole-rock geochemical data from most Universities and the CRCs, as these do not store data in standardised formats nor do they maintain central registries of digital data.

Descriptive data on field characteristics, mineralogy, etc., of both granites and sediments, and association to known mineralisation was manually retrieved from literature and compiled into a structured text file using a simple template. Geochemical plots and compilations of average geochemical values were automatically drawn from the geochemical database and also included in the report. For each suite, 31 variation diagrams were generated, and an additional 26 other criteria were captured. This text file was made available to sponsors as a hard copy written report.

From the written reports 61 attributes for the granites and a further 42 for the sediments were codified (mostly numerically) and entered into the GIS. The written reports thus provided an audit trail back to the data used to compile the GIS and also back further to the source documents. It is important to emphasise where possible, information captured by the project was from primary data, which could then be used to independently verify those interpretations that were incorporated (e.g. I-type vs S-type granite; fractionated vs weakly fractionated). This approach also enabled clients to use the same primary data to generate their own alternative interpretation. Furthermore, in areas where new data become available, it is easy to incorporate these into the database.

The Proterozoic Granites project was also novel in that it numerically codified geochemical trends as displayed on traditional XY plots or Harker variation diagrams. To do this the maximum/minimum limits for each element were calculated for the complete data set, so that the geochemistry of any one granite suite could be directly compared to any other, no matter where on the continent it occurred. A simple numerical schema was derived to classify the trend as strongly decreasing (1), weakly decreasing (2), flat (3), weakly increasing (4) and exponentially increasing (5). Figure 3a shows the template used for codifying the trend for each suite. As an example, in Figure 3b it can be seen that the Barrow Creek suite (Arunta Inlier, NT) has an exponentially increasing trend for the Rb/Sr ratio, so a value of 5 was entered in the GIS (an example of which is in Table 1).

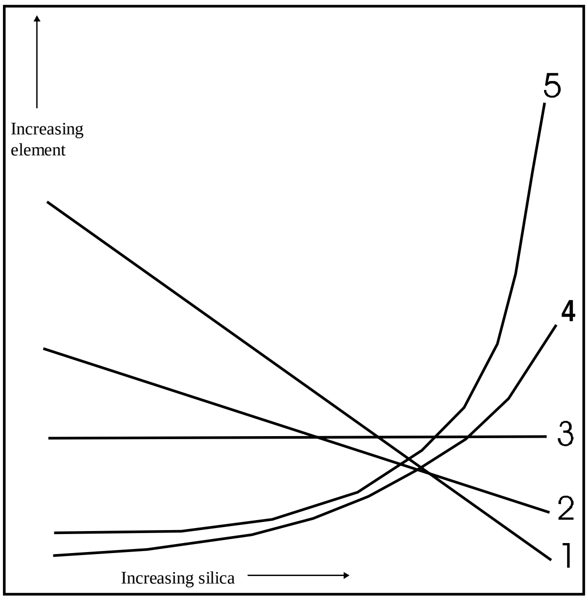

Figure 3a: Template that the Proterozoic Granites project used to classify geochemical trends.

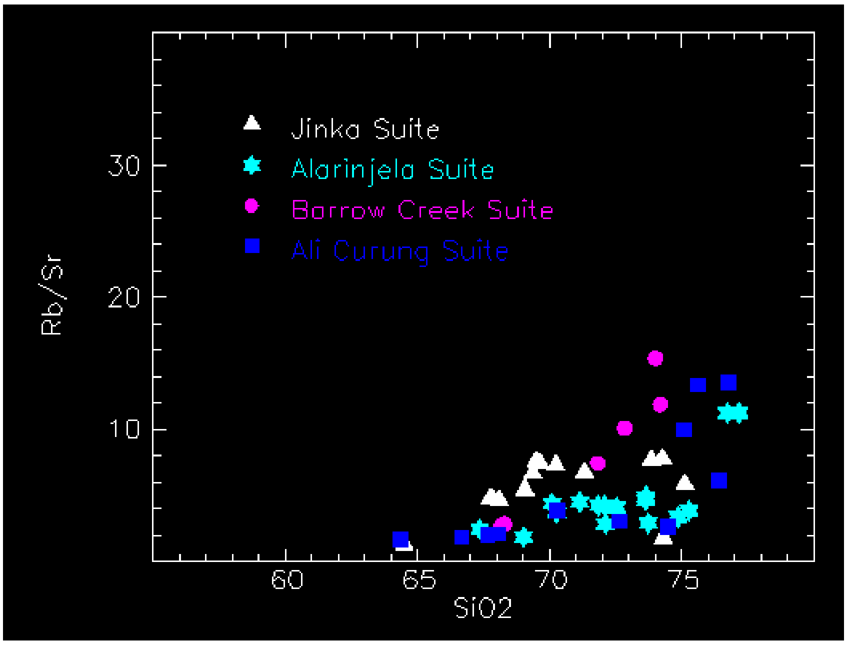

Figure 3b: An example of the numerical classification of geochemical trends of granites. By applying the template in Figure 3a, the Barrow Creek suite is assigned a value of 5 in the Rb_Sr column of the granite data table (Table 1). By numerically classifying the geochemical trends it is possible to use geochemical behaviour as a criteria for either searching, classifying or modelling within the Proterozoic Granites project's GIS.

SUITE	SUITE_NO	CU	AU	PB_ZN	SN	MO_W	RB	U	Y	P2O5	TH	K_RB	RB_SR	BA	I/S	SUBTYPE	TYPE
Barrow Creek Suite	27283	0	0	0	3	3	5	5	4	3	3	2	5	1	S		Allia Creek
Barrow Creek Suite	27283	0	0	0	3	3	5	5	4	3	3	2	5	1	S		Allia Creek
Barrow Creek Suite	27283	0	0	0	3	3	5	5	4	3	3	2	5	1	S		Allia Creek
Barrow Creek Suite	27283	0	0	0	3	3	5	5	4	3	3	2	5	1	S		Allia Creek
Barrow Creek Suite	27283	0	0	0	3	3	5	5	4	3	3	2	5	1	S		Allia Creek
Barrow Creek Suite	27283	0	0	0	3	3	5	5	4	3	3	2	5	1	S		Allia Creek
Barrow Creek Suite	27283	0	0	0	3	3	5	5	4	3	3	2	5	1	S		Allia Creek
Jinka Suite		1	1	1	0	3	4	5	4	1	4	3	4	1	I		Cullen
Jinka Suite		1	1	1	0	3	4	5	4	1	4	3	4	1	I		Cullen
Jinka Suite		1	1	1	0	3	4	5	4	1	4	3	4	1	I		Cullen
Jinka Suite		1	1	1	0	3	4	5	4	1	4	3	4	1	I		Cullen
Jinka Suite		1	1	1	0	3	4	5	4	1	4	3	4	1	I		Cullen
Jinka Suite		1	1	1	0	3	4	5	4	1	4	3	4	1	I		Cullen
Jinka Suite		1	1	1	0	3	4	5	4	1	4	3	4	1	I		Cullen
Jinka Suite		1	1	1	0	3	4	5	4	1	4	3	4	1	I		Cullen
Mount Webb Suite		3	3	1	1	1	4	4	2	1	4	3	4	3	I	Granodiorite	Cullen
Jinka Suite		1	1	1	0	3	4	5	4	1	4	3	4	1	I		Cullen
Jinka Suite		1	1	1	0	3	4	5	4	1	4	3	4	1	I		Cullen
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Jinka Suite		1	1	1	0	3	4	5	4	1	4	3	4	1	I		Cullen
Jinka Suite		1	1	1	0	3	4	5	4	1	4	3	4	1	I		Cullen
Jinka Suite		1	1	1	0	3	4	5	4	1	4	3	4	1	I		Cullen
Jinka Suite		1	1	1	0	3	4	5	4	1	4	3	4	1	I		Cullen
Jinka Suite		1	1	1	0	3	4	5	4	1	4	3	4	1	I		Cullen
Jinka Suite		1	1	1	0	3	4	5	4	1	4	3	4	1	I		Cullen
Jinka Suite		1	1	1	0	3	4	5	4	1	4	3	4	1	I		Cullen
Jinka Suite		1	1	1	0	3	4	5	4	1	4	3	4	1	I		Cullen
Mount Webb Suite		3	3	1	1	1	4	4	2	1	4	3	4	3	I	Granodiorite	Cullen
Mount Webb Suite		3	3	1	1	1	4	4	2	1	4	3	4	3	I	Granodiorite	Cullen
Mount Webb Suite		3	3	1	1	1	4	4	2	1	4	3	4	3	I	Granodiorite	Cullen
Mount Webb Suite		3	3	1	1	1	4	4	2	1	4	3	4	3	I	Granodiorite	Cullen
Mount Webb Suite		3	3	1	1	1	4	4	2	1	4	3	4	3	I	Granodiorite	Cullen

Table 1: A small subset of the data captured in the Proterozoic Granite Project GIS. The Barrow Creek suite has been assigned a value of 5 in the Rb_Sr field, based on the trend of the plot in Figure 3b.

One essential attribute utilised in the project was the Stratigraphic Index code for each pluton, suite, supersuite and stratigraphic name that was used in the database. It was unfortunate that we could not utilise the Stratigraphic Index code throughout the whole data set as it was found that many prominent names in the literature or on published maps of specific names have never been formalised under the existing Australian code of Stratigraphic Nomenclature (Staines, 1985), and many will never be able to be legitimised. Where a legitimate Stratigraphic Index code number could be assigned to a unit, then all information gathered by the Proterozoic Granites project could be automatically transferred to these other digital data sets, provided these other data sets are coded with the correct number.

Once the data were in a suitable format for analysis, surprisingly simple overlay-style outputs brought out the major results and highly complex digital data integrations were not necessary. In modern GIS analysis it is unusual for such a highly simplistic overlay approach to be so successful in generating such significant geological insights into the controls of granite-related mineralisation. It is easy to argue that the success of this simple approach lay in the fact that this was the first time that all of this data on Australian Proterozoic Granites was able to be viewed on a continent-wide scale, and hence the results were on the whole quite obvious. However, it could also be argued that due to the comprehensive and integrated nature of the data compiled, the data internally validated itself and therefore there were relatively few interpretations allowable.

A summation of the expert knowledge used to make conclusions from the data and information was written up along with other metadata. Figure 4 shows a summation and flow chart of one of the most important results of the project. Australian Proterozoic granites can be classified into 9 types, and each type has a particular mineralisation potential. For instance, if an explorer identifies some granites on its lease that have geochemical similarities to our Hiltaba type, then they would know to look for particular styles of Cu-Au deposits such as the world class Olympic Dam deposit. On the other hand, if the explorer found granites similar to the Kalkadoon type, then they could mostly discount the possibility of finding a Proterozoic-aged granite-related deposit in the area.

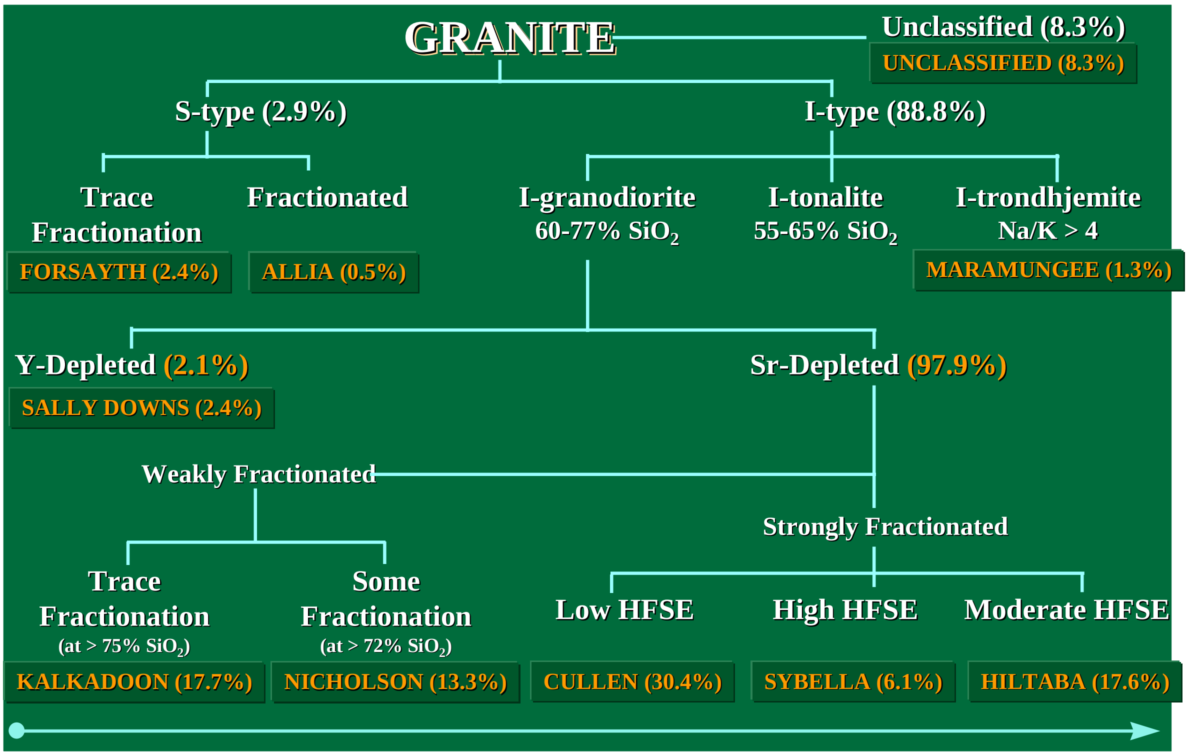

Figure 4: Flow chart summation of one of the key results of the Proterozoic Granites project: there are nine 'types' of Australian Proterozoic Granites. Each type has specific mineralisation potential.

Discussion

The digital age vs the paper age

In developing these two national-scale projects, it became clear that, in order to combine existing hard copy as well as larger scale digital data sets into single national coverages, new issues arose that need to be considered. Perhaps the most important is that, despite the capacity for digital systems to more effectively store spatial geoscience data being available for at least the last 12 years, users are still replicating traditional paper geological map making techniques in generating the digital data sets. This attitude in turn is still limiting the amount of information that can be stored on any map and a widespread concept appears to be 'generate the paper map first and then make a digital version'. Equally as well, much valuable geoscientific information is still stored in traditional written reports which in reality are long unstructured text strings and as such are totally unsuited to digital analysis.

There has also been a tendency in moving to digital systems to still compile and generate the digital data at the scale at which hard copy maps are going to be generated from that data. Instead, users should take advantage of new hardware/software opportunities to create digital data sets that far expand the amount of primary information that can be captured. These expanded data sets can only enhance our ability to analyse geological problems.

In making digital versions of some of the national scale maps (e.g. geology, metamorphic rocks) it was clear that traditional map making had limited the amount of information that could be effectively stored on the map face. The main factors that limit the information that can be stored on traditional printed maps are 1) the small amount of information that can be stored on the map legends, 2) the scale of the printed map, and 3) the fact that most printed maps can display only three themes at best (Wyborn et al., 1995) before they become too cluttered. Although in the digital age these limitations no longer apply, many digital data compilations have yet to take advantage of these new opportunities.

With a digital data set, data can be captured from the smallest detail to the broadest, and the user has the flexibility of presenting as much or as little information as is desired. Too often in generating national-scale maps geological boundaries are generalised so as to become spatially meaningless and attributes are generalised and combined into packages suitable for plotting on a single map face. By attributing detailed maps with the Stratigraphic Index code at the member level, larger scale maps can be easily generated by plotting the same map at the group level, and then dissolving all internal boundaries (e.g. Brown et al., 1997).

The digital age also facilitates not only data being used for purposes beyond which the data were originally collected, but also facilitates data models being generated for one specific project that can then be expanded into creating a much larger data set. For example, the data model used in the Proterozoic Granites project is now being expanded for 2 AMIRA projects: P482 – Characterisation and Metallogenic Significance of Archaean Granitoids of the Yilgarn Craton and P515 – Igneous Metallogenic Systems of Eastern Australia. By thus utilising a common data model throughout all 3 projects it will be relatively simple to develop a synthesis project on "Australian Granites Through Time and Their Associated Metallogeny". This particularly shows the benefits of standardised data structures and data models and is yet another example of how one set of data can be used for purposes for which it was not originally collected.

Standards

Both these national-scale projects highlighted the lack of national standards for the storage of data. This contrasts with the paper era, when considerable effort was placed in standardising nomenclature and symbols (e.g. Glaessner et al., 1948; Ragatt, 1950, 1953; Fisher, 1965). However, it is now not just names and symbols that need to be standardised and harmonised, it is also the basic data models. In the Proterozoic Granites Project, it was obvious that with some standardisation the whole rock geochemical data could be easily incorporated from the State and Territory Surveys (with the Surveys still retaining custodianship of their data assets).

Data standards are essential to allow the easy transfer of digital data from one party to another. Rigorous adherence to these standards is as important as the standards themselves, and often in large, more complex projects with several people compiling data it is easy to lose sight of these standards and to develop non-uniform data sets.

Proper codifying and attributing of data is essential in order to get as much use out of the data as possible. But just as important as the agreement on the codes used in authority tables is a definition of the meaning of each code, so that information is recorded using the same language and can be analysed with consistent results. For example, at AGSO we are currently developing a new database to record descriptions of alteration in rocks, and we have decided to reject the use of terms such as 'sericitic' or 'propylitic' because there are far too many definitions and different usages of such terms.

It is essential that digital data sets adhere to standards and rigorous quality control. Below are some of the advantages that can be gained by adhering to standards:

- Digital data sets can be quickly combined;
- Single routines can be easily written to automatically extract data from data bases for analysis, interrogation and display, rather than having to have many routines written to extract the data from each data base structure;
- Consistently attributed data will give reliable results from analysis;
- Data transfer is easy on all levels (*e.g.*, between projects and between organisations);

- Fully attributed data sets have great flexibility and often can be re-used for purposes outside the scope of the originally planned use.

National digital data standards allow more than just the rapid and accurate transfer of knowledge. They also allow better definition of ownership and custodianship of data. There have at various times been calls for a national repository of geological data. National digital data standards obviate the need for this, allowing each originating organisation to hold custodianship of their data, yet still allowing complete and rapid transfer of intellectual capital. This means that the detailed work being done by one project in its small patch of ground is available to be incorporated with data from other patches and built up into a broader-scale picture.

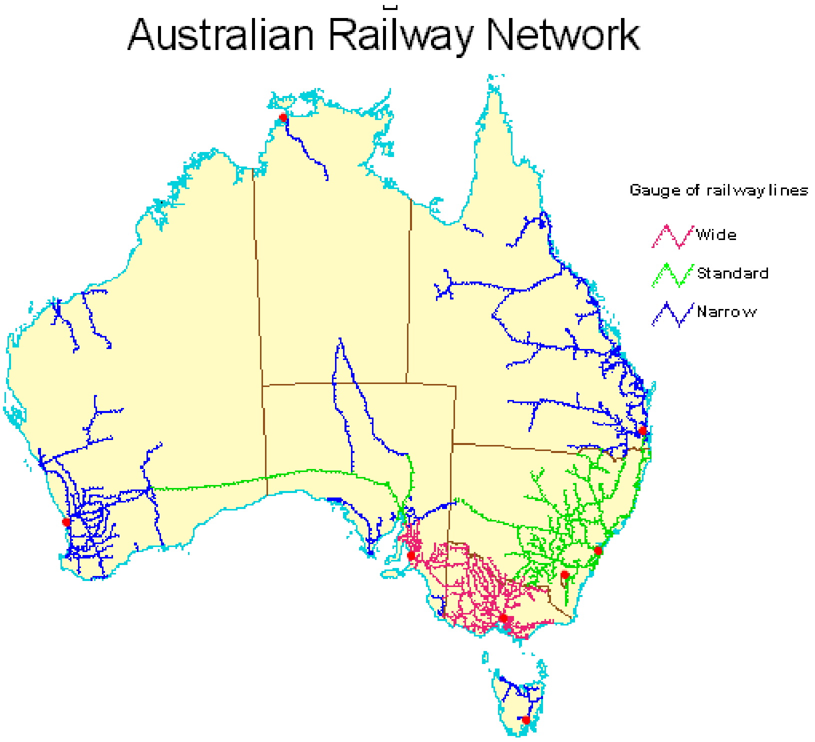

Figure 5: The status of the railway network in Australia as it had been built up until 1955. Are the digital data standards heading in the same direction ??

Figure 5 dramatically demonstrates a situation where there were no national standards. It shows the network of railways developed in Australia up until 1955. Three different gauges of line were used, making transfer between most States a matter of either unloading or reloading the trains, or of changing the bogies of each carriage adding considerably to the cost of transporting goods. Although it has taken considerable resources to improve the situation, interstate transport costs have been greatly reduced. This is a good analogy to the flow of digital intellectual capital, and serves as a reminder that without national standards for digital data being introduced as soon as possible, the geoscience community will be heading for a similar situation that will require additional resources to fix.

Archiving

Archiving of digital data is not as rigorous as it was in the paper era. Much valuable information is being lost forever, mainly due to digital outputs being both hardware and software dependant and/or digital data not following prescribed standards so that preservation in a centralised database is almost impossible. Although it was possible to gain access to the data assets of all State and Territory Geological Surveys, the same is not true of Universities and CRC's. It is unknown just how much digital more data that are being lost from the geoscientific community as once research papers have been written, there appears to be no care or consideration taken in preserving the primary data used in generating the paper in a publicly accessible, permanent database using recognised standards.

Metadata

It is also essential to have adequate metadata for national-scale data sets so that the user can know exactly what data were compiled, what the sources were and what the limitations are on how the data can be used. Metadata can also help in progress tracking how the data sets were put together, which can be very useful in understanding very large and complex data sets.

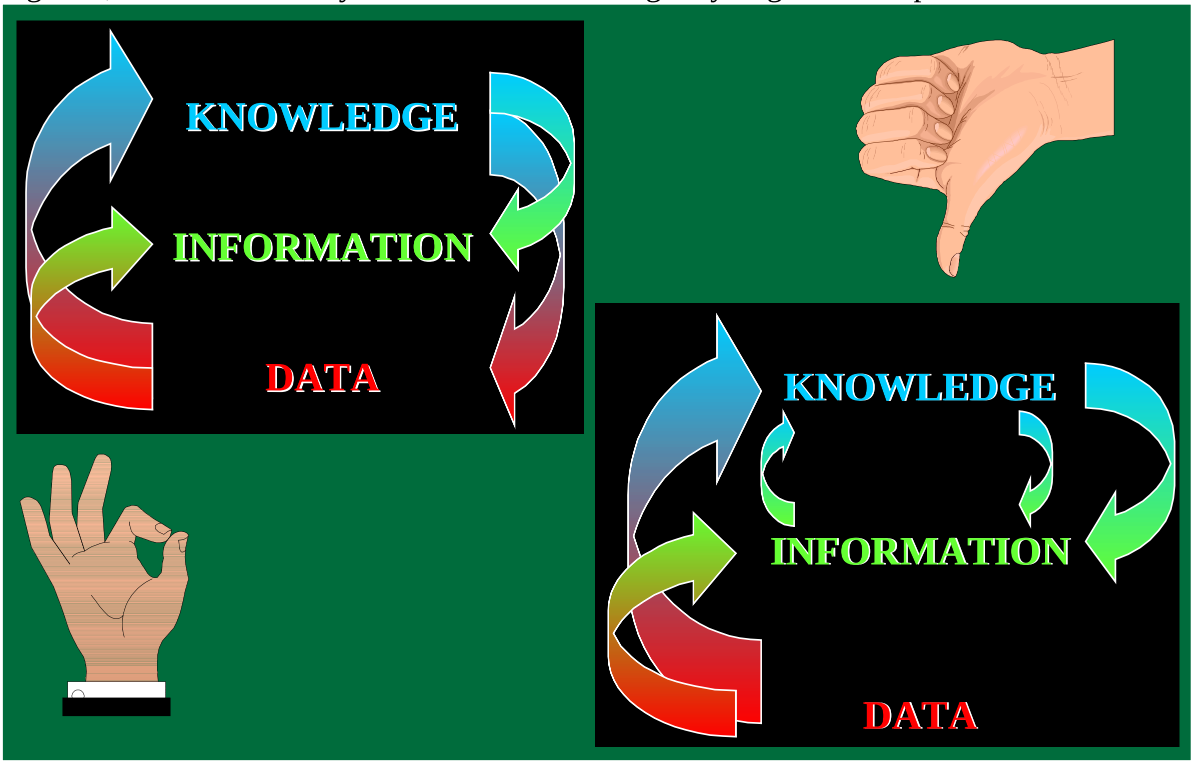

Figure 6: The ‘Knowledge management’ cycle. Information is gleaned from data by applying ‘expert’ knowledge, and the new information is used for learning and for identifying what new data needs to be collected, and the process repeats. Without care however, data can be left out of the cycle, which leads greater and greater abstraction as knowledge is derived from information without new data being added to further test the quality of the initial information. More and more becomes known about less and less.

In a good metadata system it is also essential to record the reasoning behind interpretations. It's an old adage that if you show a piece of rock to three geologists, there will be *at least* three different names for that rock. You are then left with having to make a decision as to which piece of information about that rock that you will use. Metadata can help make a decision, and allow the assignment of a level of confidence to that decision. Data must be properly captured, as should be the expert knowledge or reasoning behind the way a piece of data is interpreted, or turned into information. Care must be taken that 'knowledge' is not derived from 'information' with 'data' being left out of the cycle (Figure 6).

This is in fact basic scientific methodology of the 19th century (e.g. Kant, 1788), except that rather than being recorded in papers and journals, the intellectual capital is captured digitally, and is far more readily shared than it ever was in the paper age. Also, with each day that passes, more and more intellectual capital becomes available, and managing this is a challenge to scientists in it's own right. Active archives in relational databases clearly seem to be the best solution to this.

Conclusions

In order to carry out effective national scale analysis of digital data it is clear that there are 5 basic essentials:

1. The original digital data capture must be of the highest quality possible;
2. National Data standards are required to not only allow rapid, accurate and efficient transfer of existing digital data between geoscience and other relevant organisations, but also to enable rapid compilation of regional- to district-scale data sets into unified national-scale coverages;
3. Within any complex, long term data capture project, a high degree of discipline is required throughout the capture process to ensure consistent adherence to data standards throughout the data compilation process;
4. Long text strings must be kept to a minimum. Text data must be captured in properly structured attributes so that they are readily searchable in a GIS or database; and
5. Comprehensive metadata must be provided to ensure that the user understands precisely what data have been compiled and how it has been attributed.

ACKNOWLEDGEMENTS
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GIS compatability of digitally reported exploration data.

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The Open File Exploration Data system in Australia is one of the most valuable resources of the exploration industry. Technology has advanced to a stage where the archiving of hardcopy reports in a library represents poor usage of the resource. The optimum usage is in digital form where modern GIS and Database systems can help assimilate and analyse far larger datasets than has previously been possible. Terra Search has been collating data from the hard copy open file reports for the past 12 years. In recent years compilation rates have been up to 300 000 samples a year. Even at this rate the current backlog of exploration data will take many years to compile. During this time more and more data is being produced by the ongoing exploration efforts of companies. If we can make the gathering of the new data more straightforward, it is a realistic goal to see all open file exploration data in digital form in the future.

Various government departments around the country are currently tackling the problems of digital submittal of data. This is a major step forward. Most Companies collect their data digitally and have been doing so for years, yet very little digital data is submitted directly to the departments. Digital submittal should allow rapid assimilation into GIS and Data Management systems.

Several of the key issues for government in the collection of exploration data in digital form are:

- It must be of more use than the current hard copy system.
- There needs to be careful verification of files to ensure the data is complete
- The storage of digital files on a server is of little advantage. Access to files will be similar to getting books from a library.
- There is little advantage in digital data if it is not self explanatory i.e. you still need a Hard Copy report to interpret the data.
- Detection Limits, analytical tecniques and geological codes must be detailed to ensure geochemical data is complete.

Compilation of the data into a standard format will allow explorers rapid and effective access to the data. Data stored as separate files within a larger system will be an improvement on the current system. However, it will still require the costly and time consuming process of evaluating a series of reports/files to ascertain what information is stored within the files. These searches would still need to be based on broad spatial searches such as tenement areas.

A single database would allow interrogation of individual samples based on any criteria. These samples can have the same impact on exploration decisions as samples collected by the company, at a fraction of the cost. The database does not need to be a particular format. It must have the following basic criteria:

- must be able to store all available attributes for a sample
- should be able to store the parameters of a particular survey.
- must be able to locate data spatially for GIS use – either as a point or region.
- must be able to store metadata on regions.
- must store all tenement, bibliographic, sampling and analytical criteria.
- should be easy to extract the information into GIS, database or flat file formats.
- should be in a format easily accessible to a GIS system

- should easily accept data from a multitude of sources

The main concern has to be the information. A system which promises online wonders is of no use unless the underlying data is sound. Any process that makes the information more accessible should be embraced. Any process that compromises the integrity of the information should be avoided.

Best results will be achieved by:
- Flexible submittal procedures with detailed submittal criteria. i.e. data submittal in any format as long as it contains at least the mandatory fields.
- Careful verification of files
- Standardisation into a comprehensive format

Regulation of the digital reporting will initially need to be more rigorous than present practices for hardcopy reports. Exploration Companies will respond to a system that improves efficiency for both submitting and retrieving data in the Open File system.

Digital reporting of exploration data has the potential to save the industry a large amount of effort both at the time of submittal and when accessing the information for future exploration. It is up to the government departments and companies to ensure that this effort saving does not come at the cost of the information itself. The compilation of data into a coherent and consistent database will result in significantly greater benefits over the current hardcopy system.

Modern mineral potential modelling, quantitative resource assessment and the valuation of geoscientific data

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Abstract

Organisation mission statements indicate that the fundamental role of Australian State Geological Surveys is to record and interpret the regional geology of each State/Territory. Mission statements also show the principal client groups targeted by the State Surveys as the exploration industry, and to a lesser extent Government. From this basis, a quantitative valuation study has been made of Australian State Surveys with the specific goal of establishing the 'worth' of current programs upgrading state Government geoscientific infrastructure. The study has been done from the perspective of the community as a whole and has been undertaken in two phases reflecting the different objectives of the State Surveys in terms of the exploration industry and Government policy-making. This paper reports on the second phase of the valuation process - measuring the impact of upgraded data held by State Geological Surveys on Government mineral policy decision processes.

Standard valuation processes require modifications in order to value geoscientific information. In this instance 'worth' of regional geoscientific data is not determined as a direct valuation of the information itself but is based on changes to outcome and/or the risk associated with decision processes as a result of using improved/upgraded geoscientific data. Considering Government mineral policy decision-making, the underlying premise is that for existing 'first' and upgraded 'second-pass' data sets there will be a different probability that a deposit, when present, will be detected. This approach to the valuation of geoscientific data introduces a significant technical component with the requirement to model the probability of deposit occurrence for two different generations of geoscientific data.

This paper describes the estimation of mineral potential using modern quantitative methods and using the framework of the USGS three-part quantitatve resource assessment methodology. Mineral potential was assessed for porphyry-copper-type deposits in part of the Yarrol Province, central Queensland and is defined in terms of:

- Zones favourable for the occurrence of such deposits (prospectivity modelling). The statistical technique 'weights of evidence' is used in a general PC GIS software environment and programmed in the GIS modelling language 'Avenue'.
- Grade and tonnage models. Local variations to global models are considered to ensure estimates of the tonnages of remaining undiscovered deposits are not biased.
- Estimates of the number of potential undiscovered deposits (probability of occurrence modelling). Four guides are used including expert estimation, results of the prospectivity modelling, deposit density and base-rate estimates from well-explored regions favourable for porphyry occurrence.

Results obtained from the quantitative assessments are considered in terms of medium and long-term benefits to the state through the improved management of mineral resources. Improved management is expressed in dollar terms through the maintenance of royalty revenues into the future. It is concluded that critical decisions regarding the role and funding of State Surveys increasingly need to be made from the basis of systematic, quantitative appraisals of the worth of geoscientific data to Government. Continuing developments in technology and technical applications have not only increased the need for the reassessment of the costs and benefits of

specific types of geoscientific data, but also are providing the means by which credible quantitative assessments of data can be made.

Introduction

Organisation mission statements show the principal client groups targeted by the State Surveys as the exploration industry, and to a lesser extent Government. The focus of Australian State Government Geological Surveys on the exploration sector and the socio-economic benefits to be derived from their activities continue to raise organisational and Governmental questions. Fundamental questions include whether or not the resources committed are appropriate and in economic balance with the total benefits to be derived from their employment. Another is the degree to which such services should be funded by the community in general. These questions in turn raise important issues regarding the role and cost of the State Surveys, the impact of their services and how they should maximise community benefit from their activities and expertise. This paper reports on the second part of a two-part study valuing Australian State Government Surveys. More specifically this paper is concerned with quantifying the 'worth' of current programs upgrading State Government regional geoscientific infrastructure, in terms of Government decision-making processes.

Quantitative resource assessment methodology and modern mineral potential modelling techniques are used in the valuation process. Resource assessment, concerned with the probability of a mineral occurrence and in particular potentially economic resources, is used to provide economic meaning to physical geology. The USGS quantitative three-part assessment methodology[1] (Singer, 1993) is the framework used for the assessment of both existing 'first-pass' and upgraded 'second-pass' data sets. This methodology incorporates information on geological uncertainty and ensures internal consistency between modelling stages[2]. Most important, however, is the flexibility of this methodology, which allows the use of a range of modelling techniques which can be applied dependant on factors such as the scope of the project (eg. purpose, expertise, time available), the data available, the exploration history, and modelling environment (eg. computer support).

A variation to most assessments made using the USGS methodology is the inclusion of modelling for prospective ground. This additional modelling step is used to support the estimation of the number of unknown deposits (Figure 1). Applications used to combine and analyse data in the identification of prospective ground do not provide the probability of locating an ore deposit nor do they estimate the total number of undiscovered deposits in a region. Mineral prospectivity modelling techniques, however, do identify areas favourable for a deposit occurrence and can be used as a guide in the process of estimating the number of undiscovered deposits – in the way that 'process constraints' is discussed (Drew & Menzie, 1993). The incorporation of prospectivity modelling as part of resource assessment is relevant to Australian State Surveys, where the principal objectives require products for both the management and promotion of State mineral resources.

This paper is presented in four sections. The first section provides background to the assessment process, considering the factors that influenced the modelling stages and the techniques used. The second section discusses the assessment process, using the Yarrol region, central

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[1] As the name implies this methodology is usually discussed in three stages: (1) delineation of areas according to the types of deposits permitted by the geology, (2) estimation of the amount of metal and some ore characteristics using grade and tonnage models, and (3) estimation of the number of undiscovered deposits of each deposit type. A fourth stage is sometimes done to provide an estimation of total resources.

[2] Consistency is fundamental between delineated tracts and deposit models; grade and tonnage models with deposit models, and also with known deposits in the area; and estimates of the number of deposits with grade and tonnage models.

Queensland to illustrate techniques applied. The third section compares the results of quantitative assessments for first-pass' and ‘second-pass' data sets in terms of medium and long-term benefits to the State through the improved management of State mineral resources. The last section makes comments on the application of the methodology adopted in the valuation study.

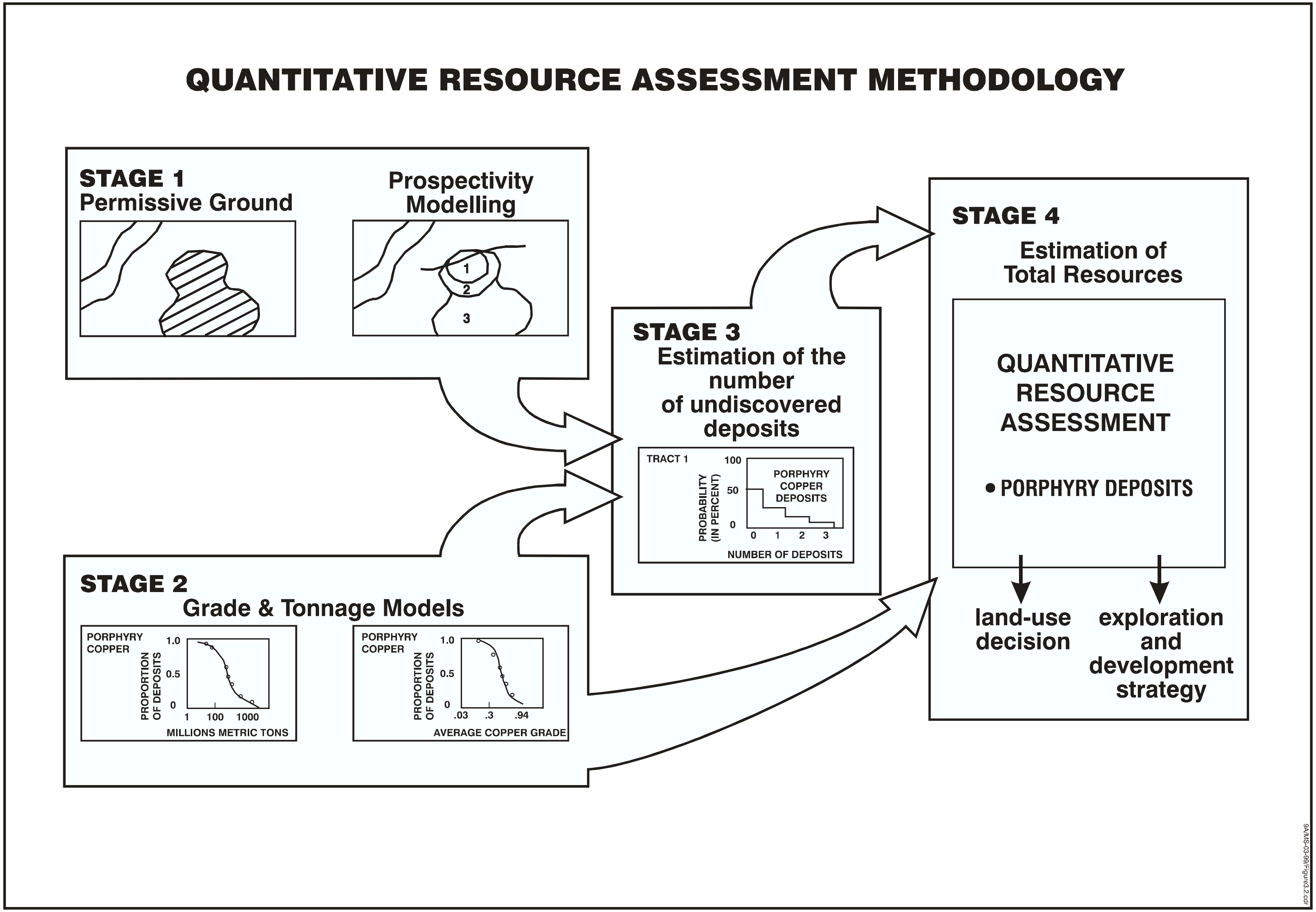

Figure 1. Schematic representation of resource assessment methodology.

Modelling considerations

Quantitative resource assessment typically involves a number of modelling stages. This section discusses factors influencing the selection of the modelling techniques used in this study, including: the scope of the assessment (purpose, time and expertise); the data available; the exploration history of the area of interest; and the assessment environment.

Scope of the assessment

Quantitative resource assessment is used to compare two different generations of geoscientific data, varying in quality, type and amount of information. Modifications to standard resource assessments have been made to suit the time and expertise available to this study. In a comprehensive resource assessment, all known and potential deposit models (those compatible with the geological environment) are used in the delineation phase to classify mineralised and barren environments and to classify types of known deposits (Singer, 1993). A team-based approach is generally recognised as the most effective way of conducting such assessments because of the range of expertise required. Time and resource limitations, however, have restricted the assessments made in this study to only one of the two main mineral types that is already known to occur in the Yarrol region - porphyry copper type deposits. The assessments made are confined not only to porphyry copper type deposits but also only to potential (undiscovered) resources that occur in this deposit type.

Exploration history

The type, quantity, spatial distribution, and effectiveness of exploration information affect estimates of undiscovered deposits (Root et al., 1992). In the Yarrol region, exploration using modern techniques is far from comprehensive, however, there are areas that have had intense exploration activity. An example is the region surrounding the Mount Morgan mine. Mount Morgan, a world-class Au-Cu mine, produced 248.8 tonnes of gold and 360 000 tonnes of copper. As would be expected, associated with such a significant deposit there has been considerable exploration activity resulting in the identification of the Moonmera and Struck Oil porphyry copper prospects. The exploration focus in this region has variously associated the deposit with the Mount Morgan tonalite, structurally controlled hydrothermal fluids and a breccia pipe system. As a consequence of this exploration activity, an area was selected in the Mount Morgan region to use as a control, both for prospectivity modelling and in the estimation of the number of undiscovered porphyry copper type deposits.

The assessment environment

A quantitative assessment incorporating mineral potential modelling and drawing on a range of geophysical and geological data is suited to a Geographic Information System (GIS) capable of analysing and integrating both raster and vector data. GIS as a general purpose technology for handling geographically referenced data in digital form, provides a range of operations fundamental to the characterisation, integration and interpretation of large and diverse geoscientific data sets. GIS satisfies the needs to pre-process data from large stores (reformatting, resampling, generalising), provides support for analysis and modelling, and post-processing of results (reformatting, tabulation, report generation). It needs to be recognised, however, that whilst the analysis and modelling functionality of current commercial GIS packages is adequate for simple geoscientific models, with increasing model complexity the use of specialised programs outside of or dynamically linked to the GIS is required. In this study Arcview 3.0 software with the Spatial Analyst extension was customised to provide a prospectivity analysis tool. The tool designed to automate the analyses in the statistical data-driven ‘weights of evidence’ technique, handles raster and vector data sets and provides results of analyses both as tables and visual displays.

The database

Data used was provided by the Geological Survey of Queensland (GSQ) and included information representative of the Surveys' most recent second-pass data acquisition operations and pre 1970 first-pass mapping. The area for which second-pass data had been compiled and was available at the time of this research determined the extent of the study region.

Three GIS projects were established representing 'first-pass', 'second-pass', and 'control' data sets. The control data set comprised 'second-pass' data for the Mount Morgan region. Data sets include information directly acquired and that obtained by the processing of the original data into a form suitable for the definition of criteria relevant to the identification of porphyry style mineralisation. The data sets used and the processing of these data sets are briefly discussed below.

Geological data. Geological maps form the basis of any resource assessment, with deposit occurrence commonly described in terms of rock association (ie. genetic or host association) and/or structural controls (ie. fault/fold/igneous contacts). Digital geological data sets provide both visual 'map' displays and associated attribute data such as, geological age and general rock descriptions. Geological data sets at 1:100 000 scale are routinely produced in second-pass mapping projects, first-pass mapping is less detailed with maps produced at 1:250 000 scale.

Mineral deposit and occurrence data. Knowledge of the geographical distribution and geological characteristics of mineral deposits is an important part of any analysis of resources. This data is also used in defining permissive ground, prospectivity modelling, and affects the estimates of undiscovered deposits in an assessment region. The mineral deposit data obtained from 'first-pass' mapping had to be manually digitising from GSQ Monto and Rockhampton 1:250 000 geological maps. Associated point attribute tables stored information on the location, name of the deposit/mineral occurrence, and principal commodities. 'Second-pass' deposit/mineral occurrence information at 1:100 000 scale was already available in digital format with attribute tables listing location, name and principal commodities. Although more detailed mineral occurrence data are now being collected and entered in the GSQ's corporate database, this information was not available at the time of this study. Consequently, particular information such as, the classification of occurrences by deposit model, had to be appended to the existing mineral occurrence data sets. Localities used in this study were identified by Geological Survey mineral occurrence mappers as porphyry deposits, occurrences of porphyry[3], or copper (and gold) skarn deposits[4].

Radiometric data. Airborne radiometric data were collected using a standard 256 channel gamma-ray spectrometer at a flying height of approximately 80m. All data were sampled at 60-70m intervals on a survey grid flown with main lines normal to geological strike with 400m line spacing. Potassium was measured directly from gamma-ray photons emitted by ^{40}K, uranium by ^{214}Bi, and thorium by ^{208}Tl. Airborne measurements were converted to ground concentrations following methods described by Grasty & Minty (1995).

The use of radiometric data was not extensive in this study. Whilst radiometric data can be effective for helping to map lithological units on a regional scale, this application had already been done in the compilation process of 'second-pass' geological data sets, which incorporated geological interpretations made from the radiometric data. Instead, radiometric ratio data were used to discriminate for zones of significant alteration, in an attempt to eliminate responses of Jurassic detrital material. Ratios of Th/K were generated using ERMAPPER software, and

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[3] A deposit differs from an occurrence in that it is a concentration of mineral of sufficient size and quality that it might, under the most favourable circumstances be considered to have economic potential (Cox *et al.*, 1986).

[4] There is a continuum between copper porphyry and copper skarn deposits, although there are important grade and tonnage differences between members of this continuum (Cox & Singer, 1986).

imported into Arcview 3.0 as a georeferenced raster file from Arcinfo, grided to 100m. Radiometric data were representative of those obtained in the 'second-pass' data acquisition programs.

Magnetic data. The airborne magnetic data had a sampling interval of 6-7m and flight line spacing of 400m. The data were used as georeferenced raster files, resampled at 100m. Processing using ERMAPPER software included reduction to the pole, first vertical derivative and C-norm filtering. Processed data sets were imported via Arcinfo into the Arcview 3.0, with the Spatial Analyst extension enabling analysis of these raster data sets.

Magnetisation boundaries were used in this study to supplement information on second-pass geological maps regarding intrusive bodies, their lateral extent, and presence under cover. Magnetic data were used for interpretations of granitoid rocks based on aeromagnetic signatures and extrapolation of these signatures to areas of either no exposure or no data. The lateral extent of magnetic plutonic bodies was also interpreted from the associated magnetic signature, using processed magnetic data to identify boundary features. Horizontal and vertical gradient processing was used to highlight non-horizontal boundaries between intrusives and rocks that have distinctly contrasting magnetic properties. These boundaries may represent faults, other geological contacts, or abrupt limits to altered rocks. Magnetic interpretation of fault/linears were also incorporated in the second-pass GIS database.

The Yarrol study

This section briefly describes the assessment process and the results obtained for the Yarrol region. The headings refer to the main modelling stages: identification of permissive ground, identification of prospective ground, grade and tonnage data, and estimation f the number of undiscovered deposits.

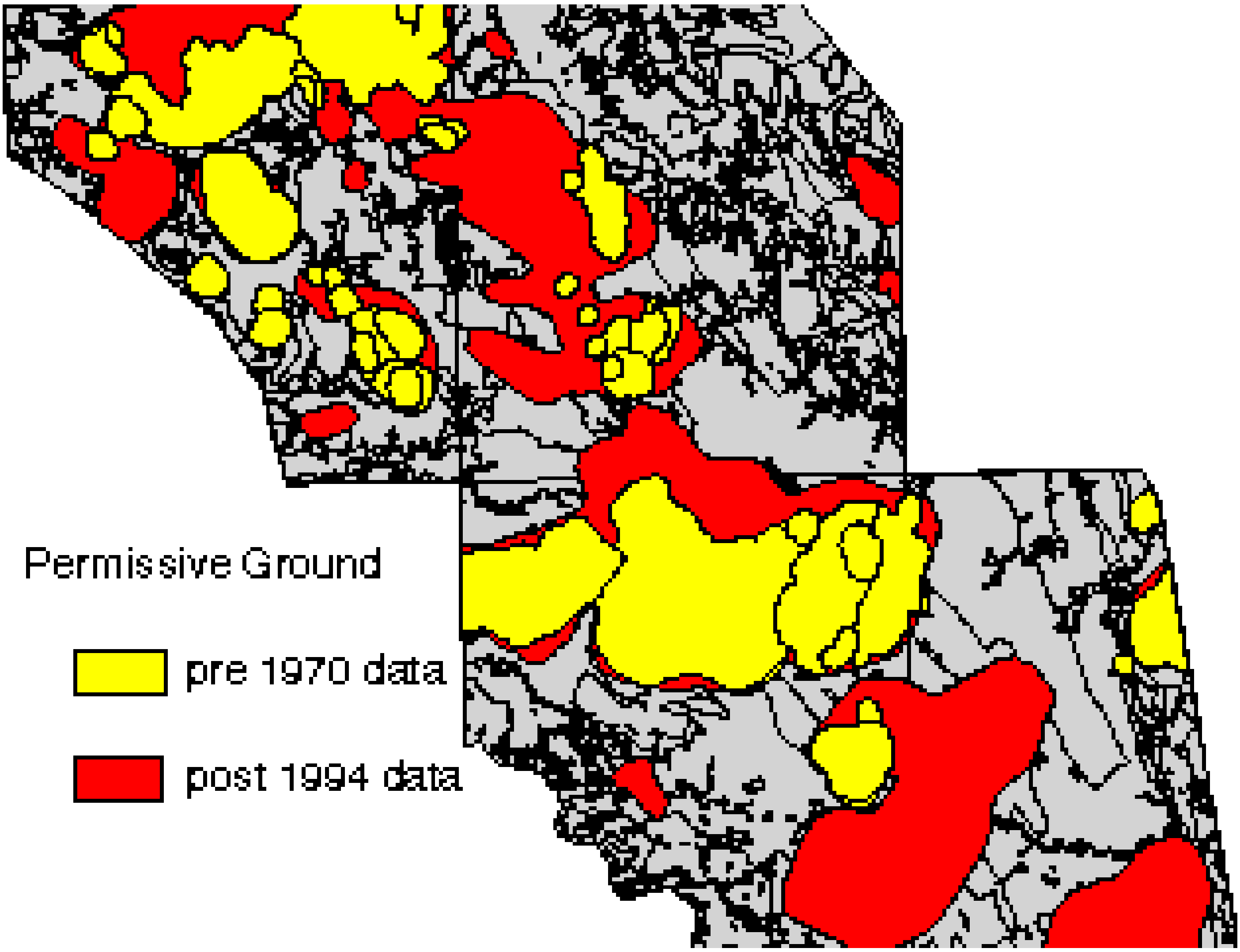
Identification of permissive ground

Resource assessment typically begins with the delineation of potentially mineralised tracts from barren ground. Permissive boundaries are defined such that the probability of deposits of the type delineated occurring outside the boundary is negligible (Singer, 1993). For the Yarrol study, permissive was defined based on the association of porphyry deposits and skarns with intrusive bodies and the vicinity of intrusive contacts. A known association between Permian-Triassic intrusives and porphyry-style mineralisation in the Yarrol region (Horton, 1982) was not used because of the chance of misclassification or exception. Instead, a more general rule was used with permissive defined as the area of exposed intrusive outcrop and the area based on a 1000m extension outward from outcrop. Also included were areas where the presence of geophysical signatures or skarn indicated the subsurface presence of an intrusive body. Geophysical data were used to identify intrusive bodies, including those under less than 300m coverage and zones of alteration/mineralisation. Figure 2 compares 'first-pass' permissive ground, based on 'first-pass' regional Government geological and mineral occurrence data, and 'second-pass' permissive ground, based on 'second-pass' regional Government geological, mineral occurrence data and geophysical data. The area considered permissive for porphyry copper type deposits almost doubled using the upgraded data set.

Identification of prospective ground

The inclusion of prospectivity modelling required the development of a conceptual model, processing of data sets, computer programming, and the generation and testing of predictor or 'factor' coverages. The gains from this additional modelling, however, are considerable with the documentation of a systematic interpretation of prospectivity, which is in turn used to support estimates of the number of undiscovered deposits within the Yarrol region. The technique 'weights of evidence' was used in this study because the Mount Morgan area was considered a suitable control. 'Weights of evidence' uses statistical calculations to estimate weights based on the measured associations between locations of known deposits and predictor map patterns. A data-driven process, such as weights of evidence, has the advantage of objectivity and reproducibility, but is restricted in its application by requiring a suitable control region, and overcoming issues such as conditional independence (refer Agterberg, 1992; Wright & Bonham-Carter (1996). Discussions of weights of evidence modelling to predict mineral potential have been made by Bonham-Carter et al., (1988, 1989), Agterberg (1989, 1992), Bonham-Carter & Agterberg (1990), Bonham-Carter (1994 a & b) and Wright & Bonham-Carter (1996). Important in this study was not the use of this particular modelling technique, but rather that the application used was systematic, reproducible and clearly documented geoscientific evidence.

Figure 2. Permissive ground for porphyry type deposits, using 'first-pass' and 'second-pass' data sets.



The general idea in prospectivity modelling is to rank and integrate information with the aim of highlighting areas prospective for mineralisation. In weights of evidence this requires the definition, extraction, and weighting of data to establish what is information relevant to the target sought. In this study six criteria were identified as possible regional scale indicators of porphyry copper type mineralisation in central Queensland - heat source; spatial association to Permian-Triassic intrusives; rock type; structural associations; alteration; and ore mineralogy. These criteria were the basis for converting multiclass maps into binary predictor maps through:

1. map reclassification - selecting for critical rock units (by composition and rock type),
2. generation of proximity maps - identifying the optimal distance to a specific feature, such as faults of a particular orientation, and
3. processing and reclassification of raster magnetic and radiometric data sets - to identify areas with anomalously high and/or low values associated with alteration and ore mineralogy that are suggestive of porphyry systems.

The Mount Morgan control served as a training area with weights and posterior probabilities generated for a range of potential predictor patterns. This information was subsequently used to identify significant patterns and associated weights, which were then applied to the entire study region, for both ‘first-pass’ and ‘second-pass’ databases. The following illustrate the process of deriving predictor coverages.

Heat source and age. Geological maps provided evidence to predict favourable thermal conditions for porphyry copper type mineralisation based on the proximity to intrusives and synvolcanic dyke swarms. Magnetic data were also used to supplement information from geological maps and surface outcrop with interpretations of the presence of granitoid bodies partially or wholly concealed by cover. All concealed bodies under less than 300m of cover were considered potentially fertile. Areas favourable for porphyry copper type mineralisation were determined by generating successive proximity buffers and plotting results to establish an optimal cut-off, in this case at 100m out from intrusive contacts.

Rock type. Horton (1982) identified granodiorite porphyry, quartz diorite porphyry and monzonite porphyry as being associated with higher-grade porphyry mineralisation in the study region. Horton discusses that ore localisation may also be controlled through preferential replacement in host-rocks, typically in carbonates/carbonate rich sediments and those with high primary permeability. Using this information, predictor maps were derived by the reclassification of geology data sets:

1. diorite/quartz diorite and areas mapped as cover overlying diorite/quartz diorite bodies,
2. carbonate-rich sediments/limestones, and
3. synvolcanic dyke swarms.

Only diorite and quartz diorite rock units were found to have a significant association with known deposits.

Structural associations. Structural ore controls referred to in porphyry deposit models include stockwork veins and breccia. Regional mapping at 1:100 000 scale generally does not identify these sorts of criteria and first-pass mapping at 250:000 does not. Horton (1982), however, reports associations with local and regional scale faults in the Yarrol region. This is supported by advice from economic geologists with expertise in the study region, which indicated an association with major north-west and possibly south-east linears/faults. Geological, regional magnetic and gravity data were used to identify linears and faults. Cumulative weight calculations were run for 'faults' within a trend range and successive proximity buffers generated. Analysis of the contrast values[5] showed only north-west trending faults to have a significant association with known porphyry-type mineralisation in the Mount Morgan Control.

Alteration and ore mineralogy. Magnetic anomalies and alteration zones are important exploration indicators for porphyry systems. Porphyry ore zones are described in deposit models as frequently being associated with magnetite-rich rocks and therefore appear as 'highs' in magnetic surveys. Alternatively, the more intense hydrothermally altered rocks produce magnetic lows. Another pattern associated with porphyry systems has magnetic lows surrounded by an area of magnetic high, reflecting hornfelsed rocks surrounding an intrusive.

Radiometric ratios of K:Th were used in this study to filter out responses from younger Jurassic sediments and highlight areas of alteration. Magnetic data was also used, but rather than arbitrarily assigning magnetic values as 'high' or 'low', actual values associated with known porphyry occurrences in the Mount Morgan Control were used. A problem when comparing magnetic values from one area with those recorded in another, is the effect of regional variation in geophysical data sets. A contrast normalisation filter (Fitzgerald & Associates, 1997) was used to overcome this problem.

Combining predictor data sets. Data integration in weights of evidence uses a Bayesian approach, introducing a probability framework. The general idea here is to estimate the posterior probability, given the presence of evidence, which may be larger or smaller than the prior probability, depending on the favourability of the predictor evidence. A number of factors need to be recognised to interpret results generated in this way. The first is that, as a data-driven process, the ranking of regions by weights/posterior probability produces a prospectivity map that is based on a statistical model and assumes that the known deposits are an adequate sample of the deposits under consideration in the region. Conditional independence (CI) of the predictor coverages with respect to the deposits is also assumed. Results obtained for the Mount Morgan control using posterior probabilities indicated a significant overall violation of CI. This is due to:

1. the identification of areas of mineralisation previously either not identified or incorrectly classified, and
2. the effect of inconsistencies between the size of the mineralising system, the point location of known deposits and the cell-size used for calculations.

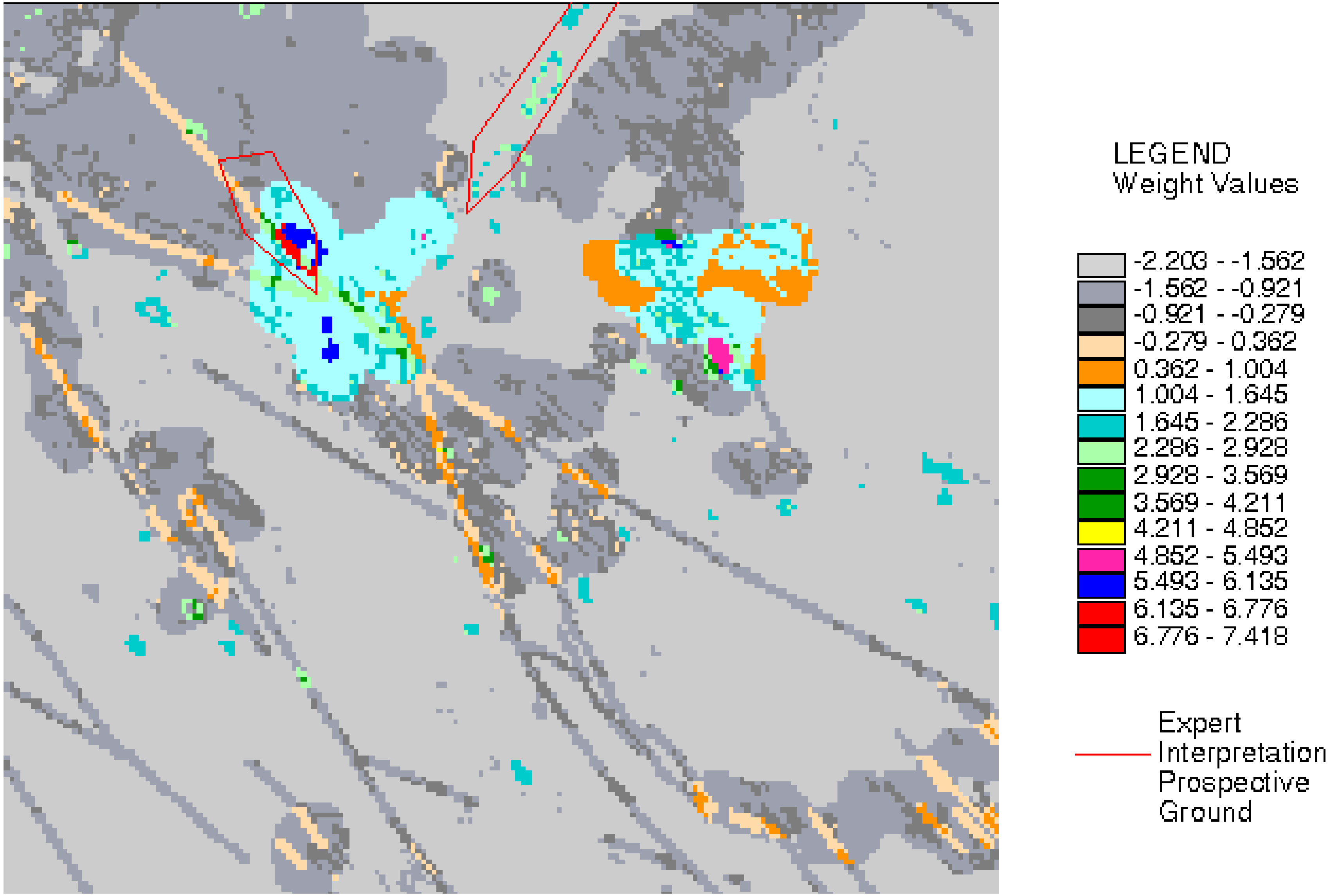
As the weight ranking of prospective ground is not affected by CI violation, weights rather than posterior probabilities were used to interpret prospectivity. It is recognised that the weight values and contrasts generated are region dependent, and consideration needs to be made that variation to the control area could affect the results generated.

[5] The contrast is the measure of overall spatial association between the binary pattern and the deposits.

Figure 3 shows the final prospectivity map for the Mount Morgan Control. Areas (1) and (2) identify where porphyry style mineralisation is known to occur, including the Moonmera deposit. Not identified in this trial was the Struck Oil deposit (4)[6]. In the south of the control, areas (3) and (5) have also rated highly for prospectivity. Area (3) has no recorded porphyry style mineralisation although, a number of small vein gold prospects do occur in this area. This suggests that the predictor data sets generated identify broad porphyry systems including associated epithermal activity. Area (5) is probably linked to mineralisation known to occur further to the north-west on a north-west trending fault zone. The red lines on Figure 3 delineate areas identified as prospective by a consultant geophysicist working with the magnetic data set for the GSQ Yarrol Project. These areas complement the prospectivity map generated using ‘weights of evidence’.

[6] Struck Oil has no surface expression. To be identified in this study Struck Oil had to be associated with a magnetic anomaly, which was not the case. It is recognised that as a pilot study, there is considerable scope for the development of strategies to more effectively deal with totally concealed deposits.

Figure 3. Weights of evidence prospectivity map, Mount Morgan control



Identifying prospective ground over the entire Yarrol study area was done using first-pass and second-pass databases, and applying weight values generated from the Mount Morgan Control. Inspection of the resultant prospectivity maps showed very different results. Defining 'target' as an area with spatial dimensions of >500m^2 and ranking in the top 10 percentile of weights, the second-pass prospectivity map for the Yarrol study area identifies two areas where mineralisation was already known to occur – Mount Gordon and Moonmera. There were 10 potential target areas ranking in the top 20 percentile of weight values, and 56 areas above a 50 percentile of cut-off. In contrast, the highest ranked areas in the first-pass model equated to the 50 percentile cut-off on the second-pass model and only had 12 localities identified.[7] Noteworthy is the difference in the number of targets identified and the disparity in ranking between the different generations of Government data. Moonmera a significant sub-economic outcropping porphyry deposit was not identified using the first-pass data, as well as number of other areas of known porphyry copper type mineralisation. A significant reduction in discovery risk was associated with the upgraded data set and an increase in prospectivity.

At this point of the resource assessment process, information has been produced on permissive and prospective ground for both first-pass and second-pass data sets, which is used later in the estimation of the number of undiscovered deposit. It is worth noting that, as a pilot study there is considerable scope for fine-tuning in the application of prospectivity modelling. Uncertainty associated with the results could be reduced by further work on data processing (eg. statistical analysis of radiometric data, classification of faults - identifying first, second, third order), acquiring additional data (eg. landsat, geochemical data sets), and trailing other modelling techniques (eg. neural networks).

Grade and tonnage models

Grade and tonnage models are used to derive the mineral endowment of undiscovered deposits in the assessments made[8]. Local variations to global grade and tonnage models (Cox & Singer, 1986) were considered to ensure estimates of the tonnage of the remaining undiscovered deposits were not biased[9]. As there are no comprehensive publications of grade and tonnage models for Australian deposits and because of the small number of economic porphyry deposits in Australia, 'local' grade/tonnage data was compiled from all known porphyry deposits of eastern Australia. Included were deposits of the Au-Cu type (eg. Cadia-Ridgeway), others that have been described as intrusive related Au breccia deposits, but are also part of Cu-Au porphyry systems (eg. Red Dome, Mount Wright, Mount Success and Mount Leyshon), Cu-Mo porphyry copper type (eg. Moonmera, Briggs), and in the case of Mount Cannindah, a Cu-Mo deposit overprinted by later Au mineralisation. Deposit examples used include some that are currently sub-economic and have had either insufficient Cu/Au or fracturing to make an economic deposit or have not been thoroughly assessed by drilling.

World-wide grade and tonnage models (Cox & Singer, 1986) show typical porphyry deposits with median values of: 500 Mt with 0.42%Cu (porphyry Cu-Mo); 140Mt with 0.54%Cu (porphyry Cu); 100 Mt with 0.5% Cu (porphyry Cu-Au). Porphyry copper type deposits in Queensland, such as Moonmera, Briggs and Mount Cannindah, range from 100-200Mt with a Cu content commonly about 0.2%. Considering a broader grouping including porphyry copper type deposits of eastern Australia, grade and tonnage distributions better approximate the USGS Cu

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[7] Areal extent is not considered, as data sets that identify criteria that reflect the extent of porphyry systems (ie. alteration/ore zonation) were not present in the first-pass database.

[8] Grade and tonnage models are developed using information from discovered deposits. Discoveries have been made with current technology and therefore it is assumed that the estimated undiscovered resources are discoverable, however, no discovery model is involved in this methodology and the estimates are made of undiscovered resources in place. No assumptions are made regarding exploitability.

[9]Singer (1993) also noted the reverse situation, with problems in the construction of grade and tonnage models in local areas because they have only been partially explored. Refer to work by Chung et al., (1992); Singer & Mosier (1981); Chung (1990).

and Cu-Au models. However, lower grade and tonnage values are still recorded for median and tail end members (median values at about 40 Mt with 0.3%Cu). Estimations of the number of undiscovered deposits made in this study were based on the information available from porphyry copper type deposits known in eastern Australia.

Estimation of the total number of undiscovered deposits
Following Singer (1993), estimates of this number of undiscovered deposits were made at the 90^{th}, 50^{th} and 10^{th} percentiles. Uncertainty is shown by the spread of the number of deposits estimated associated with the 90^{th} to the 10^{th} percentile quantiles. Favourability is represented by the estimated number of deposits associated with a given probability level. When making these estimations a number of information sources were considered including, grade and tonnage information, information acquired about exploration activity, and geoscientific data indicating ore forming activity. Some simple models were developed using this information to support estimates for the number of undiscovered porphyry copper type deposits within permissive tracts. As with the other modelling stages undertaken in this study, two estimates were required. One estimate was made for the tract identified as permissive using first-pass data sets and a second was made for permissive ground identified using upgraded data sets.

Model 1 was based on intense exploration and detailed geological knowledge that exists over the Mount Morgan Control area. Following a technique described by Root et al., (1992) the assumption was made that the most explored part of the tract was typical in the number of deposits. A Poisson distribution was then used to estimate the number of deposits in the tract, which together with grade and tonnage information, suggested that for second-pass data there were 4 deposits in the Yarrol study area with 100Mt Cu, as compared to 3 deposits with greater than 100Mt Cu using first-pass data. A problem with this approach is the definition of the control area, with deposit density sensitive to boundary changes. Root et al., (1992) also reported that other studies suggest that Poisson distributions underestimate the variability of a deposit occurrence.

Model 2 used results of prospectivity modelling. As target areas do not necessarily indicate the presence of an economic deposit, model 2 involves the development of rules following the well established idea of counting and assigning probabilities to anomalies (Reed et al., 1989, Cox, 1993). Targets were identified for first and second-pass data sets using results of earlier prospectivity modelling. Three rules were applied to the target numbers and using information from the Mount Morgan Control: 1) targets in the top 10 percentile were assigned a 1:1 ratio to deposits; 2) targets ranking in the top 20 percentile used a ratio based on the number of targets to known deposits in the control area; and 3) for targets ranking above the 50 percentile, the generalisation used was that only one in ten systems was likely to be mineralised.

Final estimates were based on target ratios and grade and tonnage data. Results for the second-pass prospectivity modelling of the Yarrol study area suggested that only one deposit was likely to be greater than 100Mt in size. For the first-pass prospectivity modelling of the Yarrol study area an estimate of one deposit at the 10 percent level of confidence was made with none having tonnage >100Mt. It needs to be recognised that in this approach some deposits may be present that are not identifiable because of the modelling technique and/or information used.

Model 3 was based on subjective estimates for the number of deposits made by Government geoscientists most familiar with the area. The estimate made used the knowledge that two deposits are known to the estimator from the study area and that these are of interest to companies but are currently considered to be sub-economic. The number of areas where the estimator considered that porphyry activity had occurred was recorded as fifteen and is listed as a 10% confidence figure. At the 50% level an estimate of seven deposits was made. Estimates assuming a 100Mt median show a marked change with one at the 50% level and three at the 10% level of confidence. Subjective estimates were only made for the upgraded data set because of the familiarity of the estimator with the upgraded data sets and the problem of transferring this knowledge to the first-pass data set.

Model 4 involved base-rate estimations from areas both favourable for the occurrence and having been well explored for porphyry copper deposits. Unlike model 1 the areas used to generate density information are not directly associated with the study region and in this case come from studies made in the United States. Information for Nevada (Cox et al., 1996) and Arizona (Titley and Anthony, 1989) describes the estimation of base-rate figures for porphyry occurrence[10]. In the example from Nevada a base-rate is suggested of 0.00015 porphyry deposits/km^2 and from Arizona a base-rate of 0.0012 porphyry copper deposits / km^2 is suggested. Combining this information a reasonable estimate for the number of undiscovered deposits within the second-pass permissive tract may range between 0.6 - 4.4 and for first-pass permissive tract, 0.3 and 2.25.

Undiscovered porphyry deposits in the Yarrol study area

Results from all four models are used to base final estimates at 90, 50 and 10% confidence levels. The figures reflect greatest confidence in results obtained through prospectivity modelling and expert opinion. Base-rate figures provided an idea of reasonable upper limits that could be expected for estimates.

First-pass and second-pass data sets – estimation of the number of undiscovered deposits

	Confidence level 90%	*Confidence level 50%*	*Confidence level 10%*
First-pass data	-	1 or more	1 or more
Second-pass data	-	3 or more	5 or more
First-pass data & >100Mt	-	-	-
Second-pass data & >100Mt	-	1	3 or more[11]

The value.of upgraded geoscientific infrastructure

The economic value of Government regional geoscientific data is estimated in terms of the economic penalties incurred as a result of incorrect Government decision-making in resource management – for example land-use, sustainable and strategic development. Improved management is expressed in dollar terms through the maintenance of royalty revenues into the future. Government geoscientific data are linked to new royalty revenue at the most fundamental level because of the requirement to ensure that land containing potential future resources is not sterilised for mining. For the minerals sector Government geoscientific data underpins input to land-use decision processes. The assumption is made that State Governments will want future mining royalties, as a minimum, to be maintained at their current level. Estimates of royalties lost with the depletion of current resource stocks over time are used as the basis for 'future new' revenue estimates and are calculated using:

- estimates of 'mine life' of major metallic mines and known hydrocarbon resources in Queensland, and
- the percentage contribution to State royalty revenues by gold, base metal and petroleum.

Two cases are considered - the first is the case where current programs of upgrading geoscientific data continue to receive funding and the second where only first-pass geoscientific data is available. Two scenarios are presented for each case. The first scenario takes a conservative position with community benefits determined from estimates of the impact of

[10] The American studies were made on Cu porphyry systems rather than a general grouping of cu/Cu-Au/Cu-Mo porphyry systems.

[11] These estimates suggest that there is limited confidence from what is currently known of a deposit present, however, indications are that there may be 3 or 4 potentially present.

geoscientific data on future royalty revenues. The second scenario takes a broader view of community benefit, recognising not only future royalty revenue but also the fact that mining companies reinvest a percentage of profit (eg. exploration expenditure). Cash-flow calculations are generated taking into consideration a number of factors, including lag time and shelf life. The concept of negative information is also recognised. The final estimate of economic losses to the State caused by not upgrading geoscientific information infrastructure is determined using the concept of a loss function. The loss function being the net benefit foregone, or the difference between the benefits generated using upgraded data minus the benefits generated only using existing data.

Relevant is that results generated through the spatial analysis of geoscientific data can be used to explicitly measure/quantify the impact of government geoscientific data in economically important decision processes. Mindful of the limitations of the study, the results obtained suggest that the area defined as permissive doubles in response to new information acquired through the upgrade program. An increase of 3.5 times is obtained for estimates of the number of potential undiscovered deposits[12]. Based on this data it is clear that there is a significant increase in both ground considered to be prospective and in the understanding of potential mineral resources associated with upgraded data sets. A justifiable weighting of 70 percent of the ‘future new’ royalties can be given to ‘second-pass’ data. Earlier first-pass data identifies an area about half the size with reduced prospectivity and greater uncertainty attached to results. Much of the permissive first-pass ground will have been already extensively although not exhaustively, explored[13]. A 30% contribution to ‘future new’ royalties can reasonably be given to first-pass data.

Conclusion

The combination of quantitative resource assessment and mineral potential modelling, involving

- analysis and characterisation of individual data sets,
- integration and interpretation of data sets, and
- incorporation of information on geological uncertainty

resulted in significant information gains, for industry and government decision-making processes. The application of mineral potential modelling facilitating the role of State Surveys in promoting State prospectivity. Computer-based prospectivity modelling used for marketing, not only provides additional interpretative information to exploration clients but also provides visual impact and increases credibility. The latter achieved through the ability to support interpretations with access to original and processed data sets.

This research project found that second-pass data sets provided by the Geological Survey of Queensland supported quantitative resource analysis. Although considerable fine-tuning is required in areas such as, data quality, data processing, and the trialing of different modelling techniques, to reduce the level of uncertainty attached to results. Relevant to Australian Surveys is that the assessment process used in this study produces information in a number of formats suited to both the exploration industry (deposit models/grade & tonnage models, prospectivity models) and Government (estimates of the number of undiscovered deposits, estimates of total resources). This approach to managing data also builds on the traditional strengths of the Surveys—geoscientific data and expertise.

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[12] This study used the MARK3 simulator developed and used by the USGS (Root *et al.*, 1992), to combine estimations of the number of undiscovered deposits (for both first-pass and second-pass data sets) and USGS grade & tonnage models for Cu and Cu-Au porphyry deposits, to derive two estimates for the number of potential deposits and potential resources in the Yarrol region.

[13] Using current exploration concepts/technology.

Results of the valuation study are generated in the context of the State of Queensland and the operations of the Geological Survey of Queensland. However, similarities between the States/Territory Surveys (their primary activity being the acquisition of regional geoscientific data with the objective of stimulating exploration activity) means that results generated in this study have broader implications and are relevant to all State Government organisations involved in the acquisition of regional geoscientific data. The Surveys have a track record of providing a high standard of regional scale geological maps, mineral occurrence maps, and more recently geophysical data. Over the last five to ten years they have been moving rapidly to incorporate technological advances into their operations. New technology has dramatically increased the effectiveness of the storage, retrieval, analysis, and display of exploration and development data, particularly geographically referenced data. A major push in this time has been to place existing and newly acquired information into databases. More recently the emphasis has been on the release of GIS information packages. The aim being to provide information in formats required by the user - again the main focus here has been on the exploration industry. Complementing these advances are increasingly sophisticated methods of handling and analysing data which can provide not only a range of products better suited to the new environment of traditional client groups, but presents new ways to deal with recognised and emerging issues. In this example the problematic question of valuing programs upgrading geoscientific data are addressed using tools and applications that manipulate, analyse and support interpretation of spatial geoscientific data.

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Cities Project Risk-GIS

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Abstract

AGSO's *Cities Project* was established in 1996 with the objective of determining the vulnerability of Australian urban communities to the effects of geological hazards and, from that understanding, provide emergency managers and planners with information and decision support tools that will aid in the mitigation of geological hazards. Our mission is to conduct research that will lead to safer, more sustainable and more prosperous communities. This effort forms a major part of Australia's contribution to the United Nations International Decade for Natural Disaster Reduction (IDNDR) and the development of national risk mitigation strategies.

Although Australia has been traditionally regarded as a stable continent, geohazards have caused $1.25 billion damage annually to buildings, lifelines and the economy. Landslides and earthquakes have killed scores of people in Australia. The Newcastle NSW earthquake of December 1989 was the worst geological natural disaster, both in terms of lives and economic loss, to strike an Australian city, but a large number of buildings in various urban areas have also been damaged or destroyed by landslides, reactive clays and salinity. The Thredbo disaster of July 1997 in which 18 people were killed, is still very fresh in our minds. As Australia's population increases, our cities spread, increasing the potential magnitude of the impact of geohazards. The ageing of buildings, roads, railways, bridges, pipelines and dams may also make them more vulnerable.

The past two years has seen the development phase of the project in which techniques, methodologies and standards have been developed and tested in several 'real world' pilot studies. Using GIS and other technologies, large amounts of disparate data from many sources within the community have been collected, collated and analysed to enable us to start modelling scenario events of the key elements at risk (buildings, people, lifelines, etc) in Australian urban communities.

Though far from complete, the ultimate aim is for these decision support tools, which we fondly term as *Risk-GIS*, to become an integral management tool in communities trying to prevent, preparing for, responding to or recovering from the impact of a geohazard event.

Introduction

AGSO's *Cities Project* was established in 1996 with the objective of determining the vulnerability of Australian urban communities to the effects of geological hazards and, from that understanding, provide emergency managers and planners with information and decision support tools that will aid in the mitigation of geological hazards. Our mission is to conduct research that will lead to safer, more sustainable and more prosperous communities. This effort forms a major part of Australia's contribution to the United Nations International Decade for Natural Disaster Reduction (IDNDR) and the development of national risk mitigation strategies.

Although Australia has been traditionally regarded as a stable continent, geohazards have caused $1.25 billion damage annually to buildings, lifelines and the economy. Landslides and earthquakes have killed scores of people in Australia. The 1989 Newcastle earthquake, one of Australia's worst natural disasters, killed 13 people and severely injured almost 200 others. In addition, it generated an insured loss of $1 billion and a total economic cost of $4 billion. The Thredbo disaster of July 1997, in which 18 people were killed, is still very fresh in our minds. A large number of buildings in various urban areas have also been damaged or destroyed by landslides, reactive clays and salinity. As Australia's population increases, our cities spread, increasing the potential magnitude of the impact of geohazards. The ageing of buildings, roads, railways, bridges, pipelines and dams may also make them more vulnerable.

Our view of 'geohazards' is deliberately very broad and includes ***all earth surface processes with the potential to cause loss or harm to the community or the environment***. Whilst our focus in the *Cities Project* is mainly on the potentially fatal acute geohazards such as earthquakes, landslides and floods, the importance of the more chronic geohazards such as acid sulphate soils, coastal erosion, reactive soils and dry land salinity is also recognised.

Such a broadly based program of research obviously requires a multi-disciplinary approach. To enable AGSO, which is a traditionally focused earth science research agency, to achieve the objectives set for the *Cities Project*, a network of operational, research and supporting partners has been developed. We have been most fortunate in attracting the assistance of partners of great quality and enthusiasm. They span a very broad range of scientific disciplines, administrative responsibilities and industry sectors.

What is Risk?

We regard risk as being the outcome of the interaction between a hazard phenomenon, the elements at risk within the community and their degree of vulnerability to that impact. It can be expressed in terms of the totality of the number of lives lost, persons injured, damage to property and disruption of the economic activity due to a particular natural phenomenon. Total risk can be expressed simply in the following form:

Risk $_{\text{(Total)}}$ = Hazard x Elements at Risk x Vulnerability

Risk mitigation is the principal objective of risk management and is seen as any activity that moderates the severity of the impact, either by reducing the hazard (generally not possible); reducing the elements at risk that are potentially exposed (e.g. by evacuating people before the flood hits or the volcano erupts); and/or reducing vulnerability (e.g. by improving building standards). The aim is to limit the human, material, economic and environmental costs of an emergency or disaster, and is achieved through a range of strategies from hazard monitoring to the speedy restoration of the affected community after a disaster event.

We have adopted a systematic approach to describing the elements at risk in the community and their vulnerability to hazard impact. This description groups the various elements into the five themes of setting, shelter, sustenance, security and society (the 'five esses'). The topics addressed under these themes include the following:

- ***Setting***: basic regional topics including the physical environment (climate, vegetation, geology, soils, land use, topography, elevation, etc.), access (external links by major road, rail, air, marine and telecommunications infrastructures), population and administrative arrangements (local government, suburb and other administrative boundaries).

- ***Shelter***: the buildings that provide shelter to the community at home, at work and at play. Access to shelter is also significant, so information on mobility within the community is included here. Particular attention is paid to the capacity and vulnerability of the road network and the availability of vehicles.

- ***Sustenance***: modern urban communities are highly reliant on their utility and service infrastructures such as water supply, sewerage, power supply and telecommunications. These *lifelines* are significantly dependent on each other and on other logistic resources such as fuel supply. The community is also dependent on the availability of food supplies, clothing, medical supplies and other personal items.

- ***Security***: the security of the community is measured in terms of its health and wealth and by the forms of protection that are provided. Physically, these may be assessed by the availability of facilities such as hospitals, nursing homes, industries, commercial premises, agricultural land use, ambulance stations, fire stations, police stations and works such as flood retention basins and levees. Also important are socio-demographic and economic issues related to the elderly, the very young, the disabled, household income, unemployment, home ownership and the resources available at the fire and police stations.

- ***Society***: here we find most of the more intangible measures such as language, ethnicity, religion, nationality, community and welfare groups, education, awareness, meeting places, cultural activities and so on. Some of these may be measured in terms of the facilities that they use, such as churches, meeting halls, sporting clubs, libraries and so on. However, the more meaningful measures, such as education, relate specifically to the individuals, families and households that make up the community.

As the *Cities Project* has developed, a generic approach to the assessment of risk from natural hazards is evolving. This process is illustrated in Figure 1.

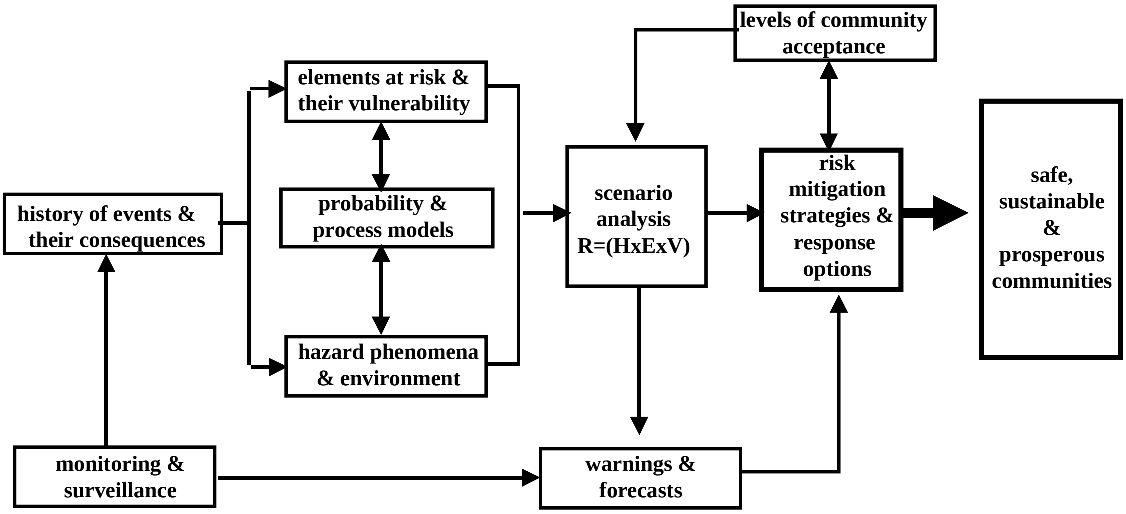

Figure 1. *Cities Project* risk assessment process.

Risk-GIS

Regardless of the scale and nature of the risk event, the reduction of the uncertainty associated with disasters is dependent largely on the availability of appropriate information. Spatial information is at the forefront in the information needed because at least 80% of all decisions made in the risk management process have a spatial content. It is also clear that the demand for information is spread throughout the process rather than concentrated in the heat of the response stage. One of the clear advantages in adopting a more holistic risk management approach is that the vast majority of data needed to prevent, prepare for, respond to and recover from a disaster can be accumulated, tested, validated and used **before** the disaster event becomes a reality. That is to say, the information and the various risk management processes it supports, become sustainable.

Clearly, the range and variety of information needed to fuel a comprehensive risk analysis is enormous. Whilst there are many sources now available from which such information can be captured or derived, much of it with the essential spatial and temporal attributes needed, there remain important gaps. Our knowledge of hazard phenomena and the processes that drive them, for example, are far from perfect. It is necessary, therefore, to develop appropriate models (process, spatial and temporal) to fill the knowledge gaps. The behavior of some hazards, such as beautifiers and floods, have an established body of modelling research behind them, whilst others, such as cyclones and earthquakes, especially in intraplate areas such as Australia, are as yet, less well served.

The synthesis of data and the essential mapping of the spatial relationships between the hazard phenomena and the elements at risk require the use of tools such as geographic information systems (GIS). In the work undertaken in our case studies, 85 to 90% of the information used has some form of spatial content. Similarly, the relationships that are most significant in risk analysis and risk assessment are largely spatial. To accommodate this spatial emphasis, the *Cities Project* makes extensive use of GIS tools and technologies.

While GIS has been used over the past decade as a tool to address specific aspects of the risk management problem, there are few examples of integrated risk management applications. There are obvious advantages in developing a fusion between a philosophy of risk management and the power of GIS as a decision support tool, hence *Risk-GIS*, as it has been fondly termed in the *Cities Project*. As such, *Risk-GIS* also provides the analytical 'engine' which drives the geohazard risk assessment process. It also provides a most potent form of risk communication through its capacity to provide a visual representation of risk situations.

Risk-GIS structure

The risk management process imposes a significant demand for a wide range of information products. To cater for this eclectic demand, *Risk-GIS* must be structured to cope with all external inputs, internal operations and output to a wide range of external consumers. Figure 2 summarises the key structural elements of *Risk-GIS*.

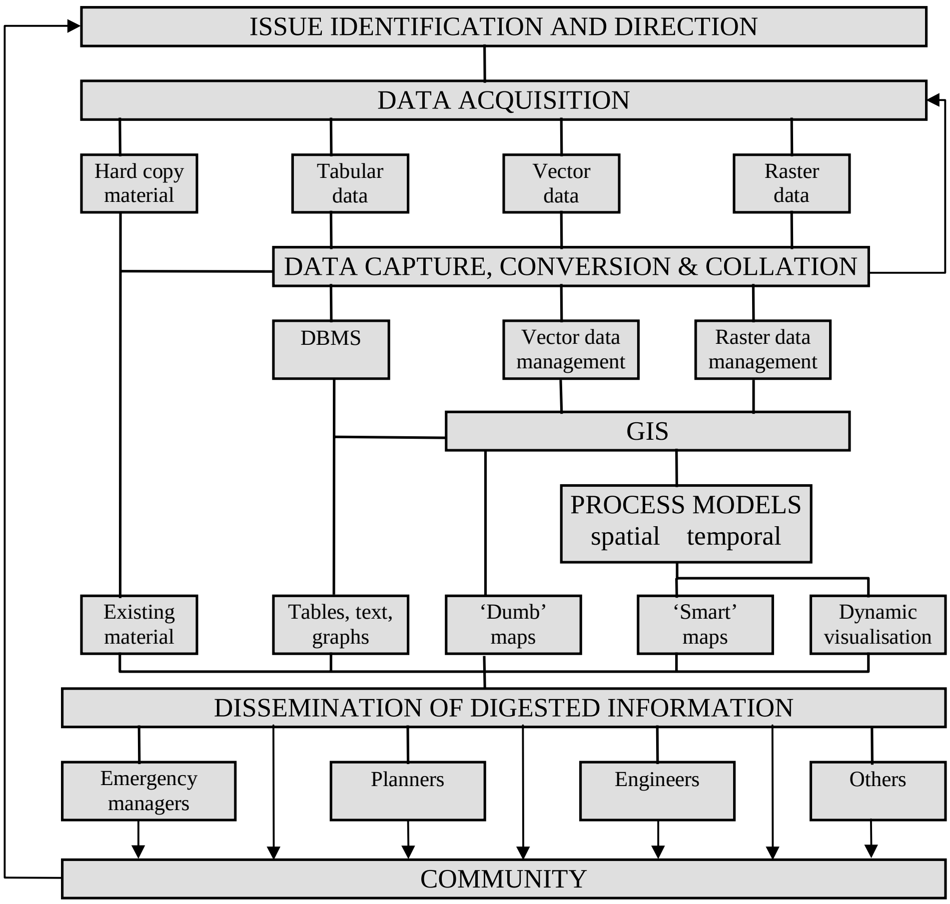

Figure 2. *Risk-GIS* structural elements.

The conventional view of GIS is seen as being made up of four elements – technology, data, people and administrative arrangements. The *Risk-GIS* model also recognises the significance of:

- the 'intelligence cycle' process, which commences with direction (identifying the questions for which answers are sought), collection (gathering the data to answer those questions), collation (the management, analysis and interpretation of the data to produce the answers) and dissemination (the communication of the answers). Implicit in this process is the progressive enhancement of data to create information and the eventual formation of knowledge and wisdom;

- the range of information products that are needed to satisfy the diverse needs of risk managers and the communities they serve. These include conventional and well established 'hard copy' products such as printed maps, books, manuals and so on; simple (one-dimensional) tables, graphs or textual descriptions drawn from databases and spreadsheets; customised, but essentially 'dumb', two-dimensional maps and graphics; intelligent, three-dimensional maps (those in which the attributes of map features contained in databases are interactively linked); and dynamic visualisation including temporal simulations, animations, virtual reality and other multimedia (four dimensional) products;

- the information infrastructure(s) that facilitate the flow of data and information throughout the model – this includes the institutional framework, technical standards, fundamental data sets and 'clearinghouse' network components that have been identified as making up ASDI (shown as the linking lines);

- the recognition that the process and structures are aimed at meeting the needs of the community as the ultimate beneficiaries.

Data—the key ingredient

The past three years has seen the development phase of the project in which techniques, methodologies and standards have been developed and tested in several 'real world' pilot studies. Using GIS and other technologies, large amounts of disparate data from many sources within the community have been collected, collated and analysed to enable us to start modelling scenario events of the key elements at risk (buildings, people, lifelines, etc) in Australian urban communities.

This collection and then integration of the many data sets has proven to be a very time consuming task. It has brought with it some associated issues that would be familiar with a lot of users of digital data, some of which I would like to mention:

- Many of the utility providers (electricity, water, sewerage, gas) have only been able to supply data in DXF format, and then only as 'dumb' graphic data, rather than 'intelligent' attributed data. Often the required attribute information is stored in a separate database with no 'link' to the graphics. Connecting the attributes to the graphics has required a significant resource.

- Custodianship and currency of the data sets. The primary candidate for custodianship and maintenance for the majority of the data sets is the local government council. It is our experience that the closer to the source of the data one could get, the more detailed, current and accurate the data tended to be. Unfortunately the provision of custodianship comes with a cost. Typically, the agencies at the local level that most completely meet the custodianship criteria are the most poorly resourced to do the job effectively.

- Access to, and cost of, data. For projects that can demonstrate a clear public benefit, as does the risk mitigation research being undertaken by the *Cities Project*, it would be very helpful if public data providers considered the loan, rather than sale, of data. The public benefit would be measured in the broader terms of enhanced public safety, rather than in a minor entry in a set of accounts. The *Cities Project* profile is now at a level where we have been able to form some very strong partnerships with many of the major data providers.

- Data confidentiality problems were encountered with some of the utility infrastructure data providers where commercial sensitivities were evident. This type of sensitivity is certainly greater where the process of the privatisation of utilities is fully developed.

- An efficient metadata documentation process is proving to be difficult due to the wide range of data sources and types. We have chosen to adopt the ANZLIC metadata pro-forma as much as possible. Because a lot of the data supplied does not have metadata itself, we have no historical information on data lineage, accuracy, quality, capture methods, etc. In these situations we are referring back to the data custodians where possible.

- There has been a major growth in awareness and interest in intellectual property issues over the past few years. It is a very broad ranging concept, but obviously the main thrust towards identifying intellectual property lies in the potential revenue to be gained from ownership of the material. Crown Copyright tended to cover virtually everything, but that is clearly changing. The *Cities Project* does not own the data provided by many of the data suppliers but has significantly 'value added' a large amount of it to enable us to complete our risk analysis. Supposedly the intellectual property lies with the Crown, but there is probably overlapping rights with the data providers.

Conclusion

We are still developing the information, the techniques and the tools needed to undertake a task as complex as assessing community risk. The projects that we will be completing over the next year or so will enable us to refine and improve on our techniques and outputs The ultimate aim is to have methodologies that can become an integral part in communities preventing, preparing for, responding to and recovering from the impact of a geohazard event..

It is imperative that we raise the awareness of geohazards in the community. As a result of the collaborative research with our supporting partners, there is already a strong level of commitment to risk management beginning to emerge. If the information and risk assessments we provide can be turned into risk mitigation strategies by emergency planners, our efforts will be rewarded.

GIS linking to external data sets and processes

Ken Moule
Exa-Min Resource Industry Consultants Pty Ltd

Abstract
This paper investigates models for management of extended geoscientific data sets, based on experience collating historic and current data sets to build a three dimensional model of the Gympie Eldorado Mine. Rather than migrate all data to restrictive GIS data structures, the consultants have integrated a range of specialist and “off-the-shelf” applications, into a unified data management model. The GeoBasemap MapLinker product is being deployed to provide active, two-way links between the MapInfo GIS and third party applications. This model accommodates extended data types such as images, word processor documents and spreadsheets, as well as managing interaction with sensitive data via database forms, rather than allowing uncontrolled edit of attributes through traditional GIS interfaces

Introduction
On behalf of Gympie Gold (formerly Devex Pty Ltd), Exa-Min is building a three dimensional model of current and historic workings. While the primary work process is digitising of mine layouts from plan, and building these into three dimensional models, project management and due diligence has required maintenance of a database of historic plans, and provision of hot-link between GIS and database representation of those plans. The project leverages off both and GIS and database technologies, and is building towards a total geosciences and mine information management system.

Historically the Gympie Goldfield was a very significant gold producer. The field provided the economic backbone that underpinned Queensland’s transition to statehood. Over a 60-year period, more than three million ounces of gold was produced from many hundreds of shafts, many of them reaching depths of over 500 metres.

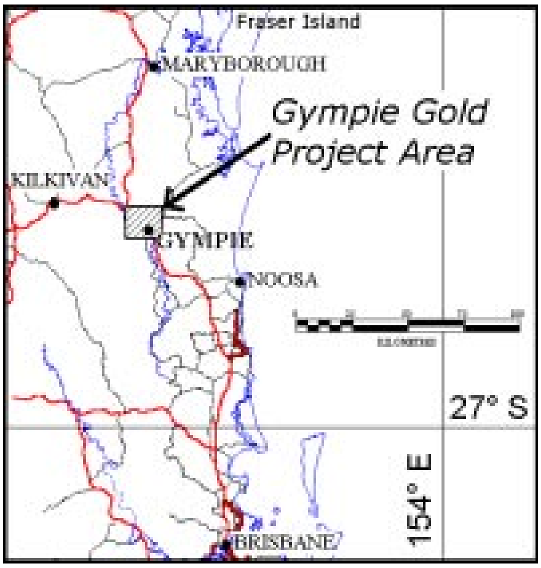

Figure 1. Location plan

Two styles of orebody have been identified. The bulk of historic production came from “Gympie Veins” emplaced at the intersection of a vertical fault set with carbonaceous sedimentary horizons. These small but persistent structures typically return head grades of around 25 grams per tonne.

Larger scale, but lower grade, mineralisation is emplaced along the Inglewood fault and associated peel-off structures.

Major exploration work and shaft renovation was carried out by BHP and Freeport in the period 1980 to 1991, under farm out arrangement. The project has now reverted back to Gympie Gold, who are now successfully producing gold from both Inglewood and Gympie vein structures.

Exa-Min has been involved in the project for around two years. The three dimensional model was commissioned, both to identify exploration targets, and to minimise the hazards that could arise were the mine to unexpectedly breach abandoned workings. The primary data set is a collection of almost 500 historic plans, many dating back to before the turn of the century.

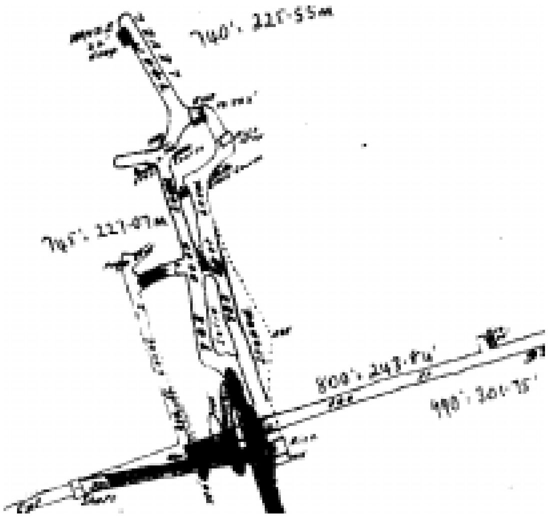

Figure 2. Typical historic plan

Work program

Historic plans were digitised into MapInfo with level and data source recorded as GIS attributes. One map layer was used to represent each level for each mine, but the data was commonly collated from a number of overlapping plans.

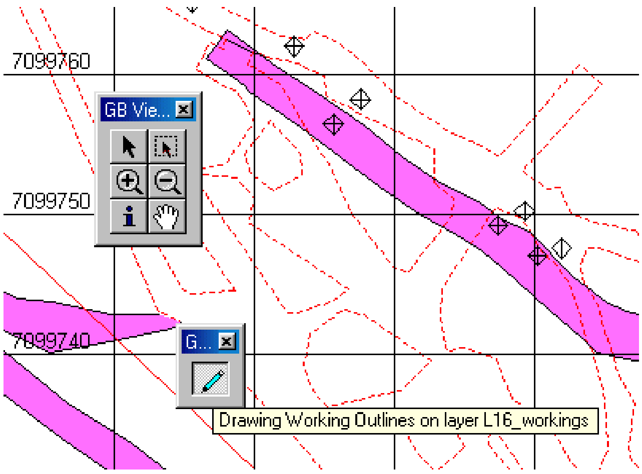

Figure 3. Digitising 2D outlines in MapInfo

Within the Gemcom for Windows mine modelling system, three-dimensional surfaces were built from survey points for each level. The two dimensional outlines were loaded from the GIS, pressed to the level surfaces and then extruded to create three-dimensional objects.

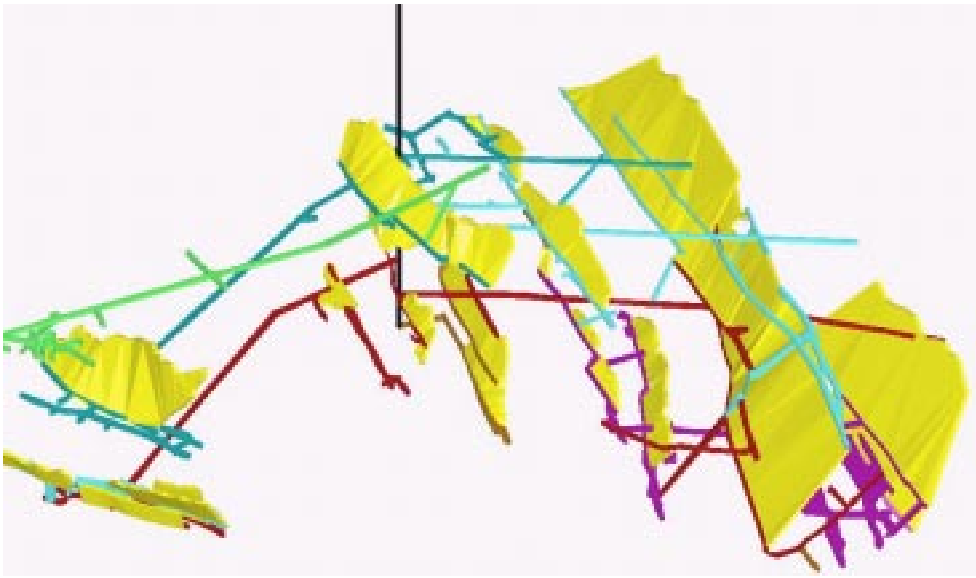

Figure4. 3D view of a small portion of underground workings.

A major technical challenge was establishing consistent survey control. Historic plans were drawn relative to magnetic north. Fortunately many of the shafts locations have been resurveyed over the last few years as part of a major shaft capping exercise. At the commencement of this project, the magnetic deviation was unknown, and has since been shown to vary across the field, and with vintage of the plans. The network of shafts and leases boundaries was reconstructed in the MapInfo GIS, to establish AMG coordinates for lease corner points, which were then used as control points for plan digitising.

While surface exploration and historic workings were represented in the GIS systems in AMG coordinates, current workings are defined relative to a local mine grid. A custom datum was defined to allow current workings to be automatically overlayed on the AMG data sets in MapInfo.

Technologies

The Gympie GIS database now contains over 1000 data layers. Managing and documenting these layers and the plans from which they were digitised, escalates the project into the realms of a serious IT data management exercise, even before you add the potential for other Geoscience data sets such as face mapping, drilling, and imagery.

The data organising functions of the GeoBasemap Images+ product, and more recently its successor, MapLinker were deployed to document the map layers and organise them into robust named views and re-useable presentation plot definitions.

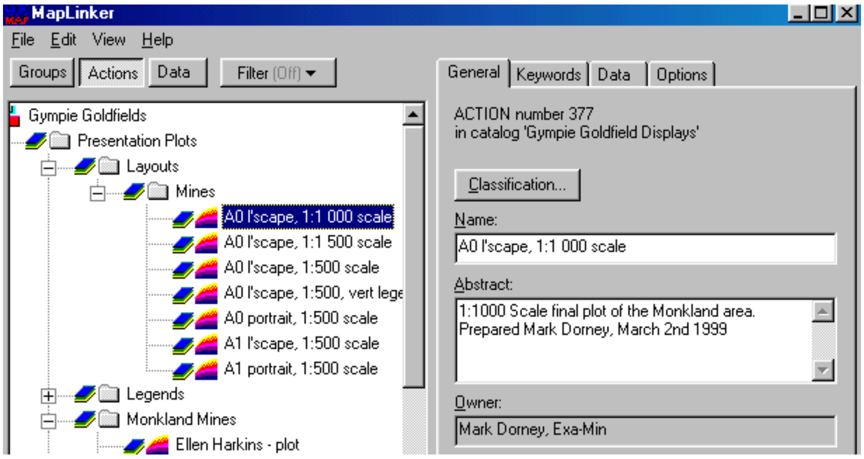

Figure 5. Cataloguing GIS maps and tables.

The complex interrelationship between Mines, Shafts, Levels, Leases and Plans dictated the application of a database system, rather management of plan information in GIS data structures.

Figure 6. Custom plans database.

MapLinker provides GIS users access to the richness of the forms interface, via two way hot-links between MapInfo and the database application. As well as providing a more intuitive interface, the database forms embody validation rules that guarantee database integrity. In Information Technology parlance, these are the business rules for interacting with the database.

This structure contrasts with traditional GIS and database integration.

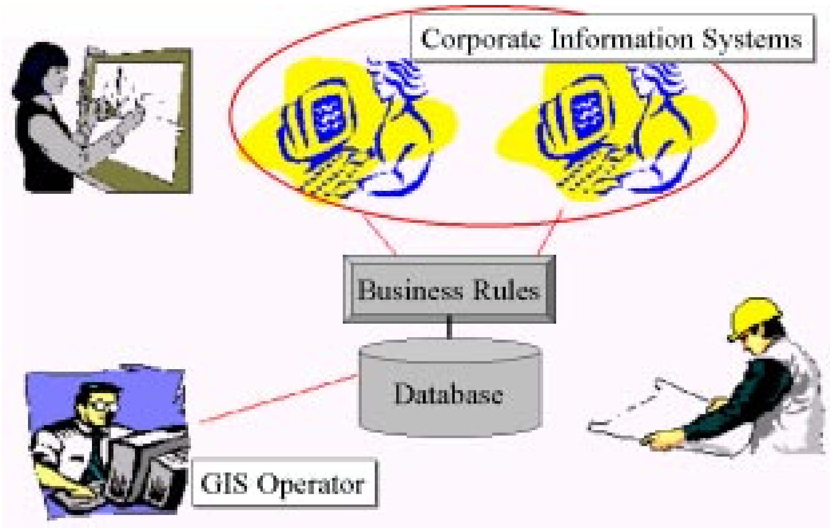

Figure 7. Traditional back door data access by GIS

Traditionally, GIS systems access the primary data sources that underpin corporate information systems. This architecture commonly bypasses data validation rules embedded in the applications that manage the data set. Complex data relationships, represented in multi-table databases, are commonly lost as data is translated into a flat-table GIS data model.

From the Information Systems technology viewpoint, computer programs embody "application processes" that interact with specific data sets, within the framework of business rules tailored for those data sets and required outcomes. GIS systems embody general business rules for interacting with spatial data, but extended attributes, and complex data types, are more effectively managed through other applications, such as database forms, image viewers, spreadsheet programs or word processors.

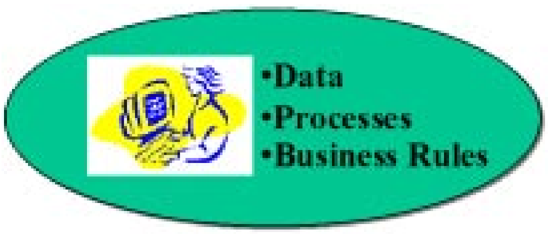

Figure 8. Application processes.

The implementation challenge is to integrate these external applications into an integrated processing model, that leverages on the most appropriate technologies to satisfy each segment of the end user's requirements.

The MapLinker product, as implemented for Gympie Gold, maintains a database of actions that describe external application processes, and provides a framework for maintaining and cataloguing these process definitions. Any MapLinker enabled application can trigger the execution of any pre-defined processes, and optionally pass additional parameters to refine the process execution.

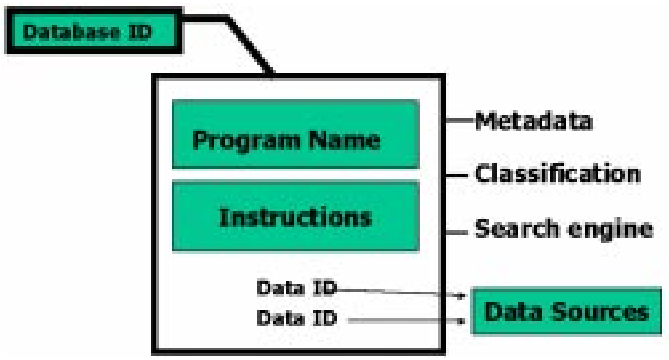

Figure9. MapLinker actions

Within the context of the Gympie project, MapLinker actions were defined which opened specific database forms, loaded with the record corresponding to a map object clicked in the GIS session.

For example, clicking on a lease with a custom tool button in MapInfo opened a database form in Microsoft Access, that allowed editing of information on the mine that occupied that lease. Clicking on the same shaft with a different tool button, hot-linked to the database form that described the lease itself. A "GIS find" button on the Microsoft Access forms, communicates back to the MapInfo session to highlight the map location of a shaft or lease.

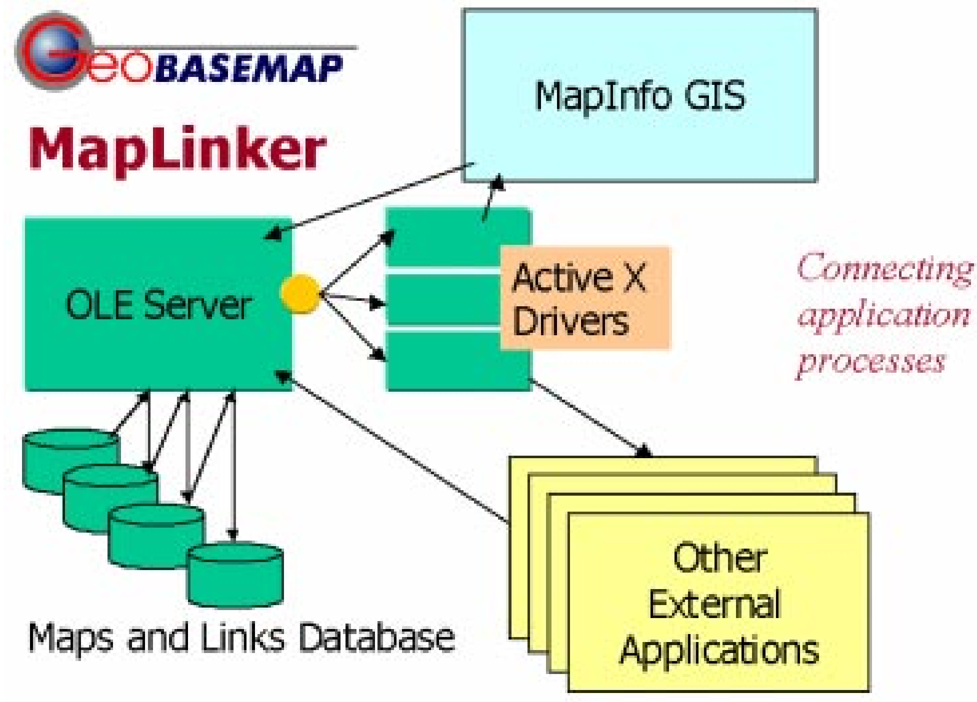

Figure 10. Connecting application processes.

Technology advantages

While the Gympie project is a significant undertaking, it is unrealistic to expect a geosciences project to carry a software development overhead. MapLinker was developed to provide an "out of the box" application integration solution, with application links customised through editing of database records, rather than custom programming.

Other vendors have trialed limited hot-linking and integration presenting forms from the GIS. What is new about the current approach, is the emphasis on leveraging off external applications rather than replicating capability within the GIS, and defining links as database items, eliminating the overhead of project specific programming. While the underlying linking technologies (OLE, DDE etc) are in common use within the programming community, the provision of high level, reusable drivers that can be configured directly by GIS consultants is unique.

While MapLinker was originally developed as a GIS integration tool, it has clear application away from the GIS environment. Any application that exposes an interface to MapLinker, effectively exposes a link to any other application MapLinker supports. The technology supports integration of "best of breed" applications into a unified processing flow.

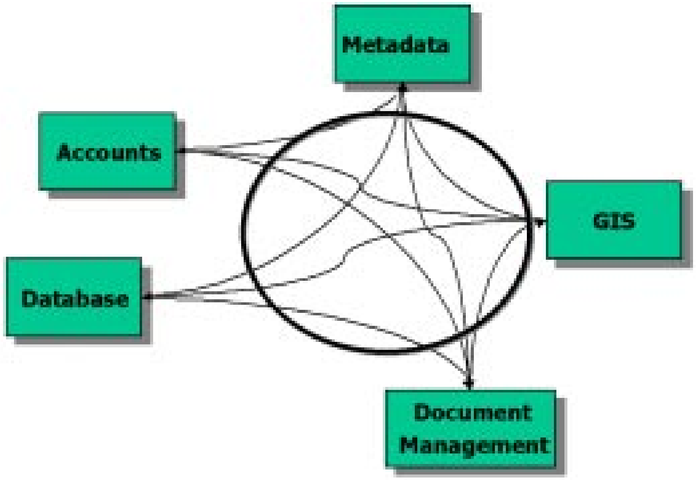

Figure 11. Linking between external computer applications.

While not all these applications are in production usage at Gympie, the Gympie MapLinker database includes working links for MapInfo, Microsoft Access, Microsoft Word, Microsoft Outlook, DataShed (Geoscience Data Management System) and the DataWorks document management system.

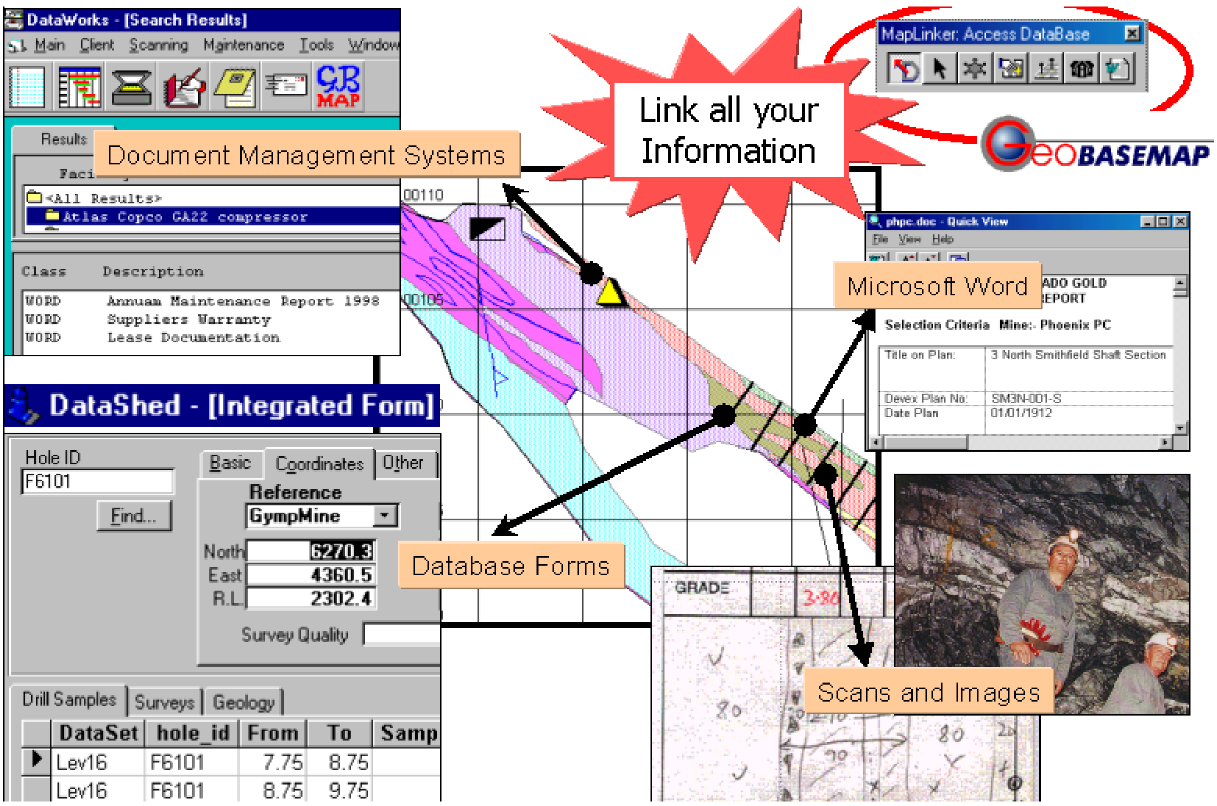

Figure 12. Linking to external data sources.

This is a new paradigm in GIS integration. It is built around GIS enabling application processes, rather than duplicating data sets within the GIS. It maximises the utility of “off the shelf” software programs and allows IT managers to spatially enable complex data sets, while maintaining those data sets in a secure environment, optimised for the data set rather than restrictive GIS data models.

Integrating databases with GIS at Pasminco Exploration: the first steps

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Two years ago Pasminco Exploration began the process of building a central database for its exploration data. Part of the vision for this database was to have it integrate as seamlessly as possible with Pasminco Exploration's GIS software.

The database primarily contains located point data (drillhole collars, surface samples) with associated geochemical analyses. These data can now be interactively displayed and queried from within both the database and the GIS.

The philosophy and tools behind this "first stage" integration will be discussed, together with anticipated future developments.

Focusing exploration in the Kanmantoo Trough

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Abstract
A basin analysis study has been recently conducted on formations hosting base metal mineralisation within the Cambrian Kanmantoo Group of South Australia (Gum 1998). This study identified stratigraphic and structural factors controlling the localisation of mineralisation. Two conceptual models were used: 1) stratabound Pb/Zn and discordant Cu mineralisation both formed by SEDEX activity during deposition of the Kanmantoo Group, and 2) stratabound Pb/Zn formed by SEDEX activity and discordant Cu mineralisation formed during subsequent Delamerian metamorphism.

The Kanmantoo Group has undergone several phases of exploration and mining since the first identification of Pb/Zn mineralisation in the 1830's (Gum, 1998 and Drexel, 1978). At present, the majority of surface outcrops have been covered by recent exploration. However, a large proportion of the Kanmantoo Group is covered to various depths by recent sediments and the Kanmantoo Group is interpreted to extend under cover of the Murray Basin, possibly as far as the Glenelg River Complex in Victoria (Turner et al, 1993).

Previous company exploration and work by PIRSA geologists has resulted in a very large amount of data being accumulated in the PIRSA database. A large percentage of this data has been compiled into the Kanmantoo GIS dataset which is available for purchase from PIRSA (Burtt et al, 1994). To further enhance this dataset, some of the data has been reprocessed and re-interpreted using ArcView and software purchased from AGSO (Gallagher, 1997) to produce prospectivity maps of the most intensely mineralised parts of the basin. The aim of this project is to outline areas where known stratigraphic and structural controls on mineralisation coincided and which have been under-explored or overlooked in previous exploration programs. It is anticipated that this work will be extended to cover other areas of the Adelaide and Barker 1:250 000 map sheets.

A 25m pixel size DEM was created from the Department of the Environment and Natural Resources (DENR) 1:50 000 digital topographic database using ArcInfo. A vector coverage of interpreted structural features was created from various sources including detailed aeromagnetic data collected during the SAEI program, the DEM, radiometrics data and mapped faults and shears. Three distinct sets of structural features were found to occur. A NW-SE set, a NE-SW set and a north south set. These features have been recognised in the past and can related to deformation during the Delamerian orogeny (Preiss, 1995). A vector coverage of all known mineral occurrences in the study area was exported from PIRSA's SA Geodata database and buffered. The association of mineral occurrences to the sets of structural features were tested using a simple ©^{2} test using the method outlined in Knox-Robinson and Robinson, 1993. The sets of structures were buffered according to these results.

Landsat TM data was also used in interpreting structural lineaments and examining the distribution of clay-rich and iron-rich soils. The Landsat data provided useful contextual data when combined with the DEM and aeromagnetics, enabling spurious features to be excluded. Viewing the data with an Abram's ratio highlighted potential zones of alteration which were then examined in the field.

Geochemical data from rock chip samples and drillhole intersections were extracted from the PIRSA database. The data were tested for anomalous populations using the cumulative frequency histogram package of Micromine. The data was then buffered according to the anomalous populations defined. Detailed geology from the PIRSA database was updated with several new

lithological members which have been recognised as having a significant control on mineralisation and buffered.

The various data sets were created using ER Mapper and ArcInfo and exported into ArcView. Map prospectivity analysis was then conducted using several models including Boolean, fuzzy logic and weights of evidence.

Introduction

The Cambrian Kanmantoo Group of South Australia, a sequence of marine metasediments, is host to numerous small Zn/Pb and Cu orebodies within its region of outcrop. The majority of these orebodies are found within the two formations that comprise the Silverton Subgroup (Talisker Calc-siltstone and Tapanappa Formation). The genesis of these deposits has been the subject of debate for many years with both syngenetic and epigenetic models put forth. Currently no deposits are being worked, however several small resources (< 1Mt) have been outlined and exploration is continuing.

Outcrop of the Kanmantoo Group forms a broad arcuate band on the eastern side of the Mount Lofty Ranges, South Australia. It extends from Australia Plains in the north, to the southern edge of Fleurieu Peninsula and onto Kangaroo Island. The area that outcrops is only a small part of the total basin, which extends for an unknown distance under cover to the east. This study has focussed of the main area of known mineralisation in the basin around the Kanmantoo Mine. Figure 1 shows locations mentioned in the text and the study area.

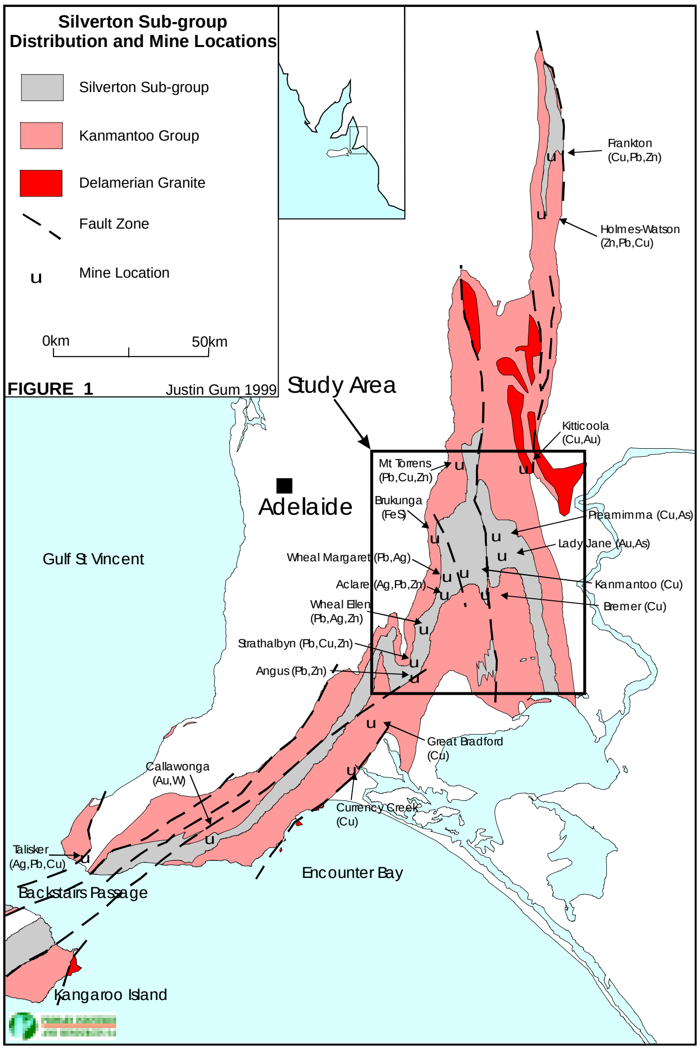

Figure 1. Study area and distribution of Kanmantoo Group (after Gum 1998).

The Kanmantoo Group unconformably overlies the shallow water carbonates of the Early Cambrian Normanville Group, which in turn rest unconformably on Neoproterozoic basement. The stratigraphy of the Kanmantoo Group is summarised in Figure 2. The predominantly deep marine, flyshoid sediments of the Kanmantoo Group were deposited in much deeper water than the sediments of the Normanville Group. The exceptions are the Backstairs Passage Formation and Middleton Sandstone, which were deposited in a shallow water environment. The sediments of the Kanmantoo Group represent a significant change in the basinal environment from that of the Normanville Group. The basin margins were defined by steep faults. Kanmantoo Group sedimentation is characterised by evidence of extremely rapid sedimentation (Gum, 1998) and there is evidence of simultaneous tectonic activity related to the onset of the Delamerian Orogeny (Gum, 1998).

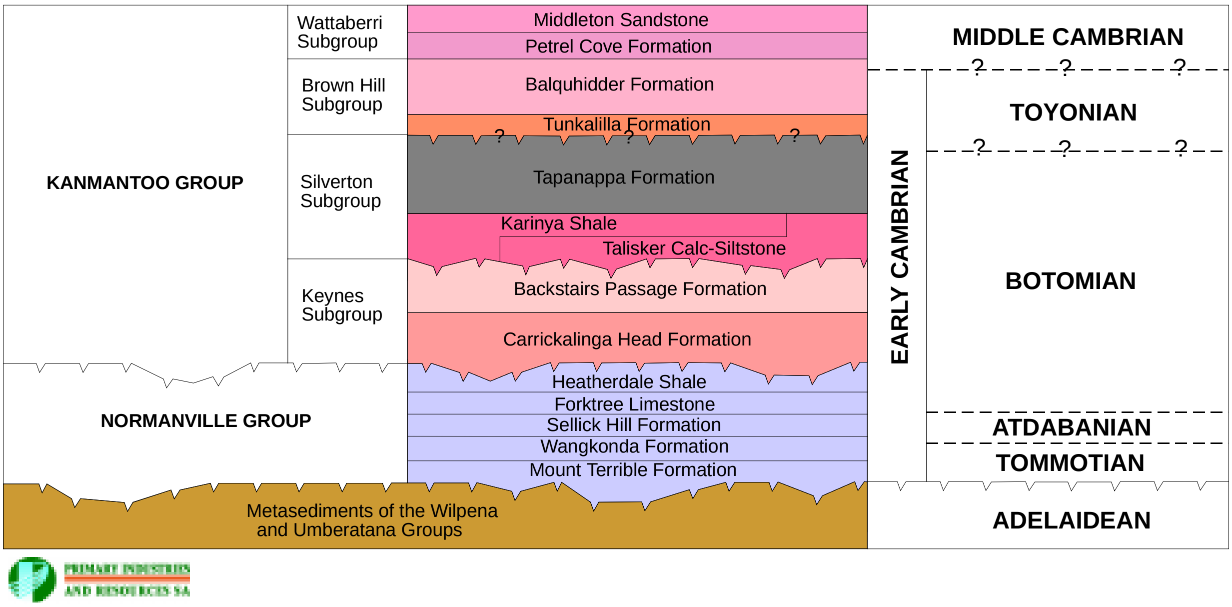

Figure 2. Stratigraphic summary (after Dyson et al 1994).

The Cambrian Kanmantoo Group has seen several periods of exploration and currently the majority of the outcrop area of the group is held under exploration licence. The rate of exploration in the area is decreasing due to the lack of recent exploration success. The majority of exploration in the region has been aimed at locating outcropping or shallowly covered mineralisation. The Kanmantoo Group also extends under cover of the Murray Basin for an unknown distance to the east. Recently, exploration interest in this area was stimulated by drilling intersections of copper and zinc mineralised volcanics and the acquisition of detailed aeromagnetic data by PIRSA in conjunction with exploration companies as part of their SA Exploration Initiative (SAEI). After drilling prospective looking magnetic highs with little success, interest in this area has dwindled.

A basin analysis study has been recently conducted on formations hosting base metal mineralisation within the Cambrian, Kanmantoo Group of South Australia (Gum 1998). This study identified stratigraphic and structural factors controlling the localisation of mineralisation. It was concluded that at least two phases of mineralisation were present within the Kanmantoo Group sediments.

Bonham-Carter (1994) outlines several methods of analysis of multiple digital datasets using GIS systems. This project uses two of these methods (Weight of Evidence and Fuzzy Logic) to analyse results and data from the basin wide study. The results are combined with the large amount of data available in the PIRSA database, with the aim of evaluating the prospectivity of the exposed and covered regions of the basin.

Mineralisation models

Several ore models have been proposed for the mineralisation occurrences in the Kanmantoo Trough. This project will eventually produce prospectivity maps specifically tailored for each of these types of mineralisation. This paper concentrates on map analysis of PIRSA data using the model proposed by Toteff (1999) and elaborated in Gum (1998).

SEDEX model A (Gum, 1998)

Detailed analysis of deposits and the sediments hosting the mineralisation have shown three main types of mineralisation occur within the Kanmantoo Group:

1) Syn-sedimentary, biogenic accumulations of iron sulphides.
2) Syn-sedimentary, exhalative deposits of base metal sulphides, iron oxides, manganese oxides and carbonates.
3) Syn-metamorphic, granite-related copper sulphide deposits.

Several other minor styles of mineralisation also occur within the Kanmantoo Group:

1) Syn-metamorphic remobilisation of syn-sedimentary base metal sulphides.
2) Syn-metamorphic, granite-related quartz/gold vein deposits.

The SEDEX style mineral deposits were formed during dewatering of the basin during deposition of the Silverton Sub-group. They are found along several specific stratigraphic horizons reflecting several pulses of fluid expulsion. These horizons are represented by the garnet-rich Angas Garnet Member of the Tapanappa Formation and the basal carbonate of the Cooalinga Sandstone Member of the Talisker Calc-siltstone. The mineralisation appears to be localised near bedding parallel shear zones (originally syn-sedimentary growth faults) and transverse fault systems. Intersections of these two types of structure may have the most potential.

Cu/Au stockwork feeder zones were probably developed along syn-sedimentary fault systems beneath or adjacent to the stratabound SEDEX deposits. During subsequent Delamerian deformation, the majority of these feeder systems were destroyed or separated from the overlying stratabound Pb/Zn mineralisation by reactivation of the growth faults. The SEDEX mineralisation is likely to have widely dispersed halos of Mn/Fe/Si rich sediment along strike and Mn enrichment of the sediments has formed the Angas Garnet Member.

Cu mineralisation is commonly found associated with the Angas Garnet Member, but the majority of this mineralisation is interpreted to be epigenetic and formed during the Delamerian Orogeny, when granite-related fluids intersected the geochemically distinct Angas Garnet Member. Proximity to granite sources and axial fold structures concentrating fluid flow are interpreted to have significant control on the localisation of mineralisation.

SEDEX model B (Toteff, 1999)

This model is very similar to the SEDEX (Gum, 1998) model above, except that the majority of Cu/Fe mineralisation associated with the Angas Garnet Member is assumed to represent footwall, stockwork feeder zones to the Pb/Zn mineralisation (Figure 3). The essential difference is that all the known mineral occurrences are combined into one dataset set with this model as opposed to Pb/Zn and Cu being split into separate sets in the above model.

MVT deposits

Potential exists for MVT Pb/Zn deposits to occur in carbonates around the margins of the palaeo-basin. The migration of metal-rich brines through the basin sediments is a requirement for both SEDEX and MVT mineralisation and they are often found in association with one another. The Normanville Group is highly prospective for this sort of deposit and several potential occurrences have been recorded (eg. Angas River).

Remobilised metamorphic base and precious metal vein deposits
Common veining and remobilisation of pre-existing mineralisation has occurred during the Delamerian Orogeny. Concentration of these fluids appears to have been associated with the intrusion of Delamerian granitoids and Delamerian folding.

Windsor (1999) studied the vein distribution and thickness across the Kanmantoo Trough and provides a basis for dividing the Kanmantoo basin into structural domains, which are associated with remobilisation of pre-existing fluids.

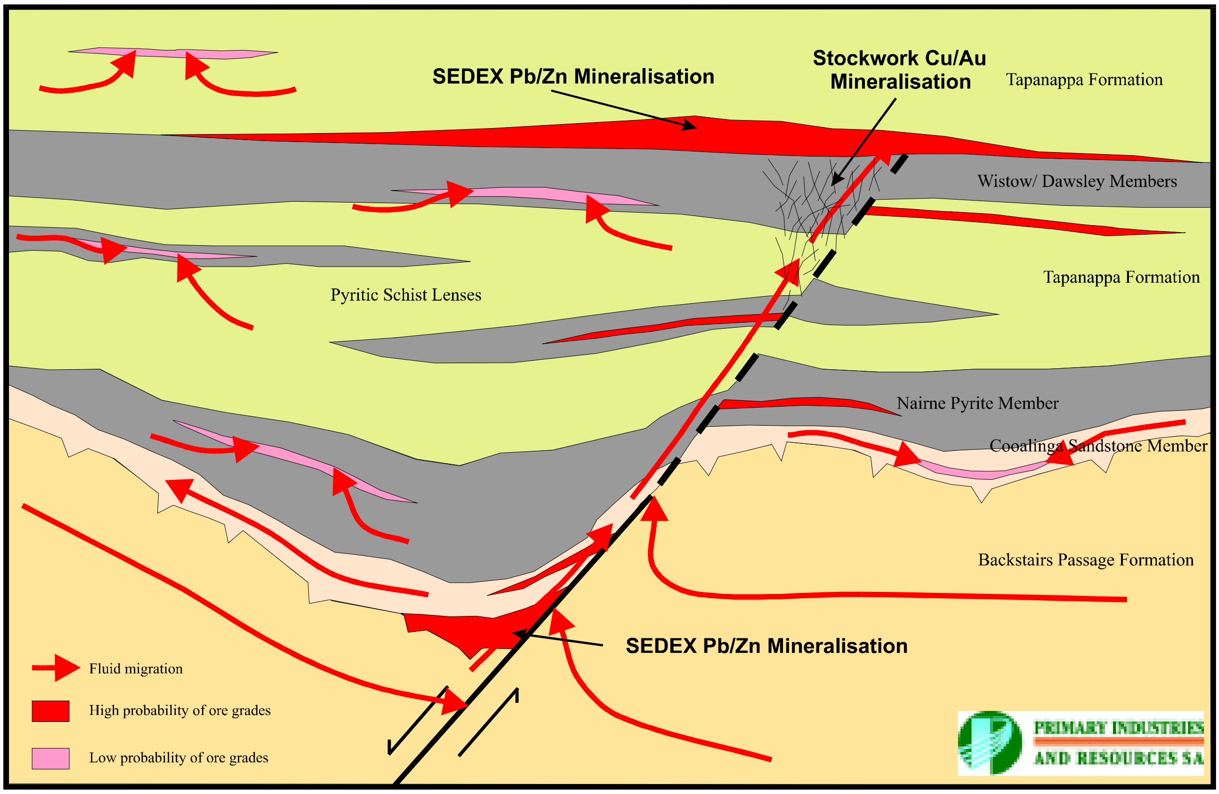

Figure 3. Stratabound base metal mineralisation model (after Gum 1998).

Datasets
Several sets of data were readily available within PIRSA's database and these were used as outlined below in the production of the prospectivity maps. The majority of the data, with the exception of the DEM, is available from PIRSA as part of the Kanmantoo Digital dataset (Burtt *et al.*, 1997).

Mineral occurrences
This dataset was derived from the Kanmantoo Digital Dataset (Burtt *et al.*, 1997) and includes the majority of known workings and mineralisation occurrences in the area. The dataset was updated with several minor mineralisation occurrences including occurrences discovered in recent exploration programs.

This dataset set was then used as the basis for Weight Of Evidence (WOE) analysis of the various other relevant datasets covering this area in the PIRSA database, using the method outlined in Bonham-Carter (1994).

Aeromagnetics
Detailed aeromagnetic data flown during the SAEI was incorporated with older, less detailed company data and were processed and imaged on ERMapper. A pseudocolour, total magnetic intensity image was used, with blue representing low magnetic susceptibility and red representing high magnetic susceptibility, to interpret linear features that represent structural discontinuities within the sediments and intrusives of the Kanmantoo Group and surrounding lithologies.

Illumination angles were varied to highlight features running in different directions and the 1st vertical derivative of the data was also used to highlight structural features.

An ArcInfo vector coverage of the lineament data was produced (Figure 4c) and each lineament was coded in ArcInfo with additional information. They were each labelled with the origin (aeromagnetic image), the reliability (known, inferred-major or inferred-minor) and type of structure (crustal, shear or fault). As every structure could not be examined in the field, knowledge of similarly orientated and sized structures was used to classify the type of structure, assigning either 1 or 0 for the separate crustal, shear, fault fields. Thus lineaments which were of regional extent and which showed evidence of both ductile and brittle remobilisation were labelled with 1 for all three fields.

Digital elevation model
The DEM was created using existing digital 1:50,000 topographic contours (10m interval) purchased by PIRSA from DENR for use within the department. This is the only data that is not available to purchasers of the Kanmantoo Digital Dataset (Burtt *et al.*, 1997). Arcinfo was used to convert this vector data into a 25 x 25 metre pixel image. Linear features were interpreted from a sun shaded pseudocolour image using ER Mapper. The extracted linear features were coded as per the aeromagnetics using our existing geological and structural knowledge of the area (Figure 4a).

Radiometrics
The radiometric data over the area was twenty years old and of very poor quality. Only the Total Count data was used as the Potassium channel had degraded beyond use.

A vector lineament map was all that could be obtained from this data. These lineaments were mainly inferred structures with a couple of definite linear features running across the entire area. This lineament data was treated in the same manner as the other vector lineament sets (Figure 4d).

Landsat TM data
An April, 1994 Landsat 5 TM image was subset to the project area and processed using the dark pixel extraction technique to remove some of the atmospheric interference from this imagery. This corrected image was processed to produce 742 RGB, Principal Component 1, Abram Ratio, decorrelated 742 RGB and Abram Ratio images. These images were used to extract linear features that were coded according to the previous criteria. Generally the extracted Landsat TM linear features correlated with features extracted from the DEM image as the topography is expressed in both data (Figure 4b).

The Crosta technique for defining pixels with high iron and clay was trialed with inconclusive results. This technique was generally unsuccessful due to the masking influence of vegetation and cultural features in this area. Areas of possible iron and clay-rich soils were defined by the ratio images, but the extensive influence of culture and vegetation make these areas difficult to extract from the image.

Combined structural lineaments
A combined structural lineament dataset was produced because in the genetic models we are using, faults and other structures have a strong control on the formation and localisation of mineralisation.

The vector lineaments sets from the aeromagnetics, DEM, radiometrics, Landsat TM and mapped faults were appended into one single vector set in ArcInfo. Even though this produces a somewhat chaotic image, several very interesting observations were made which could not have been drawn from the individual datasets.

Across the various data types, the orientation of structures is quite coherent with roughly three main sets of lineaments being present (NW-SE, NE-SW, and roughly N-S). This fits well with the current structural interpretation for the area.

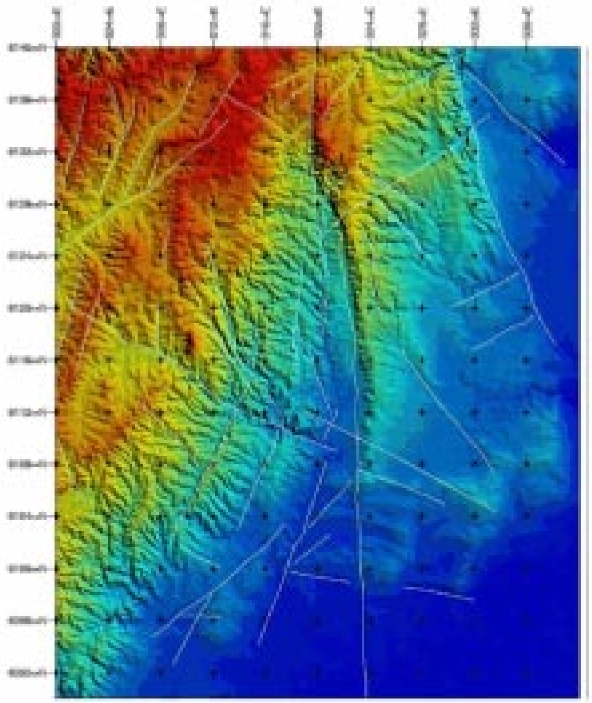

Figure 4a. DEM (25x25m pixel) with linear interpretation.

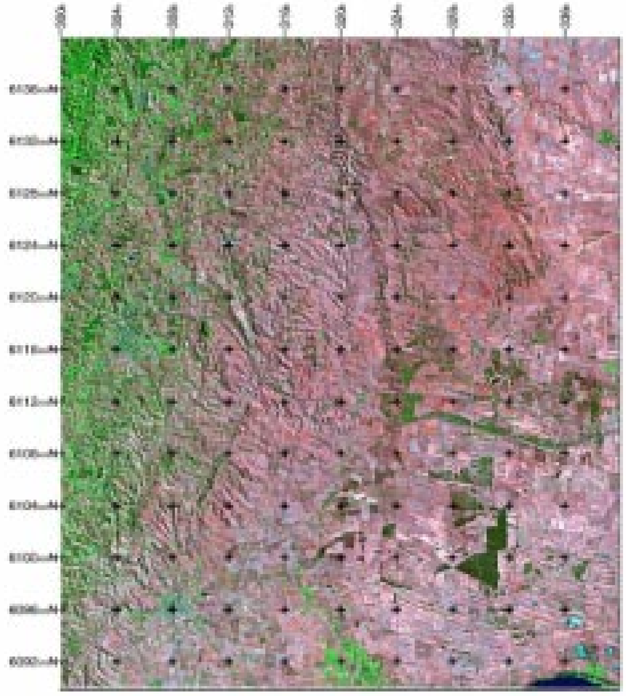

Figure 4b. Landsat TM (7,4,2 R,G,B).

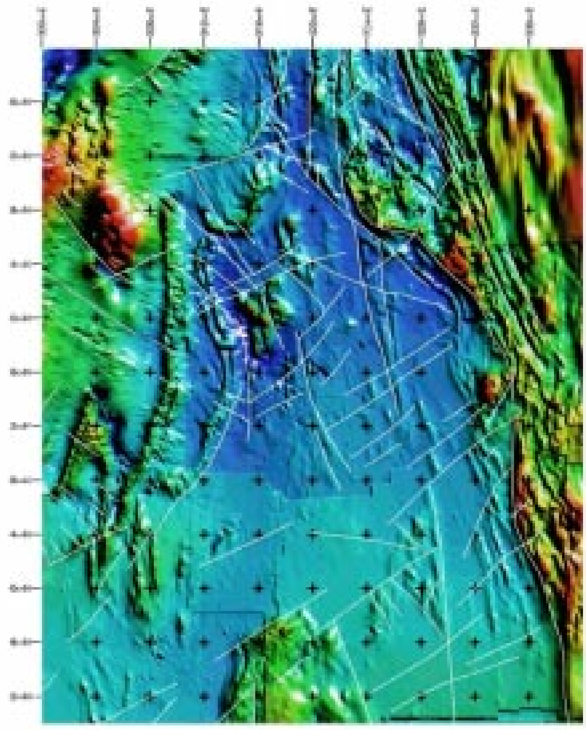

Figure 4c. Pseudocolour TMI magnetics with linear interpretation.

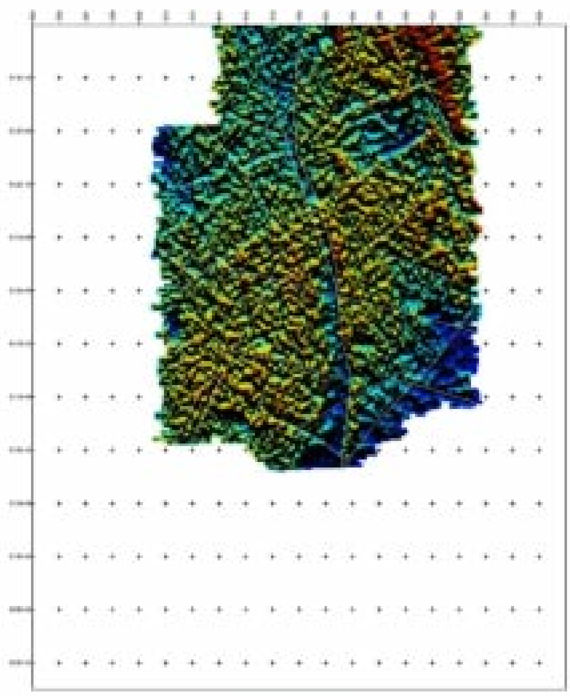

Figure 4d. Total count radiometrics with interpretation.

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One major lineament, which crosses the entire study area (NW-SE) and continues for a considerable distance either side of the study area and is not particularly obvious on any individual dataset. The combined lineament set highlights the continuous nature of the feature and indicates that it may be a major crustal structure.

A simple Chi^2 test was conducted on the orientation of the lineaments within 200m of mineralisation. This showed that there was a strong correlation of mineralisation with orientations along 30°, 60° and 110°. This data was then used in the fuzzy logic analysis of the study area. This combined lineament set was used in the WOE and fuzzy logic analysis as outlined below.

Geology

Recently, the spatial relationship between key lithologies and mineralisation has been recognised in Tapanappa Formation metasediments (Toteff, 1999 and Gum, 1998). Historical mines such as Wheal Ellen, Kanmantoo, Aclare, Strathalbyn and Scott Creek occur within the Angas Garnet and Dawesley Andalusite Members. Other smaller historical mineral occurrences are also spatially related to these units. The significance of these units to mineralisation is believed to be the relationship between the chemical sediments they represent and the (SEDEX) mineralising event/s.

Maps of several different authors have been used to produce the extent of the Angas Garnet and Dawesley Andalusite Members for the Kanmantoo and Monarto Synclines. Field checking has also been undertaken to map the extent of these units in key areas.

Fold axes

Prior to this study no detailed compilation of fold axis data had been completed within the study area. Regional scale folds were traced off the 1:50 000 geological sheets and combined with local folds obtained from thesis and exploration company maps of the area. These fold axes were labelled with type (syncline/anticline) and generation (F1/F2/F3).

While not relating to formation of the mineralisation being studied, the fold axes have a strong control on the remobilisation of the mineralisation during the Delamerian Orogeny.

As with the lineament dataset, the fold axes were subjected to a Chi^2 test to determine if mineralisation was preferentially associated with any particular orientation of fold axis. The test showed that fold axes between 10 and 30 were strongly associated with mineral occurrences. These data were then used in the fuzzy logic analysis.

Geochemistry

Geochemistry for the area was also obtained from the Kanmantoo Digital Dataset (Burtt *et al.*, 1997). This dataset mainly contained rockchip samples and recent drillcore/chip samples from mineral occurrences and prospects within the study area. No regional scale geochemical sampling was available in digital form to be included in this study.

The rockchip samples in the dataset tend to come from near known mineral occurrences and thus provided a very biased dataset not suitable for regional scale study. However the dataset was included in the study as a control dataset.

Four rough populations were determined for Pb, Zn and Cu using the cumulative probability method (Sinclair, 1991). These values were then used in the map analysis.

Map analysis

The analysis of the datasets produced above was conducted on ArcView using the Weight Of Evidence (WOE) extension (Gallagher, 1997), which employs cell-based grid modelling. This method was chosen as it is an empirical method and it was hoped to act as a check for the more model driven analysis of the Fuzzy Logic method. It was also hoped that the empirical WOE method might also provide further insights into controls on the mineralisation.

The project is ongoing and at present only a trial study area has been completed. The basic data for this project has been processed into ArcView themes for use by the WOE extension.

Weight of evidence analysis

The WOE method of analysis compares the occurrence of known mineralisation to features in other datasets (eg. fold axes). A value is assigned to the grid cells of the analysis, based on the strength of the correlation. The grids from the various analyses of datasets can then be combined into a final grid.

WOE analysis has been conducted on all the various datasets using the mineral occurrence set. Unfortunately, very few datasets returned good positive WOE correlation values and the final map analysis produced no positive values, despite using various distances and relationships. This may be due to the fact that two distinct mineralisation types (Cu and Pb/Zn) are present with different controls, as postulated in the SEDEX model of Gum (1998). The initial WOE analysis was conducted on too fine a scale (25m) and thus produced very small, high value anomalies (Figure 5). The very fine scale may have provided too much detail and thus diluted any clear association of the datasets and mineral occurrences. However, a larger scale (500m) analysis also failed to produce sensible WOE values. There may also not be enough mineral occurrence data points to allow accurate correlation with the other datasets.

Despite these problems some positive correlations were obtained. The lineament data showed very similar correlations to the Chi^2 analysis confirming these results. The strongest WOE values were obtained with the rockchip sampling. This confirms the basic validity of the method because, as mentioned above, the geochemical samples were mainly obtained from close proximity to mineral occurrences.The next step in testing the usefulness of WOE analysis in this area will be to separate the Pb/Zn and Cu mineralisation occurrences and retest WOE association with the various datasets.

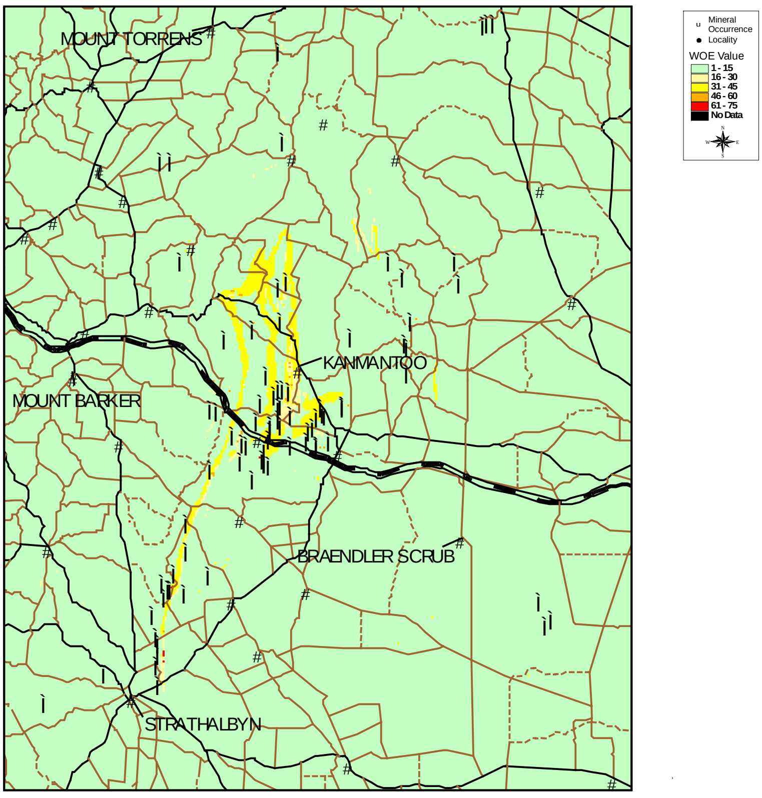

Figure 5. WOE analysis results of study area (25 m grid)

Fuzzy logic analysis
The second part of the project was to integrate controls determined from previous studies into a fuzzy logic system to produce prospectivity maps.

The fuzzy logic approach involves assigning numerical values between zero and one to features, depending on the significance of the feature in the mineralisation model. Thus part of the project had subtly different aims, being model driven, not empirical. Ranking the various controls on the mineralisation and producing the fuzzy logic analysis should not concentrate so heavily on the known mineralisation thus it should be more useful in areas where no mineral occurrences are found. However, it should also indicate that known areas of mineralisation are high prospectivity or the system is not accurate.

The map produced from this analysis (Figure 6) highlights most of the known mineralisation and also indicates several other areas of high potential, most of which have received little or no exploration in the past. The next step will be to examine these areas with rockchip sampling and drill testing to determine the validity of this method. Therefore, the fuzzy logic method appears to be more useful than the WOE method at this stage.

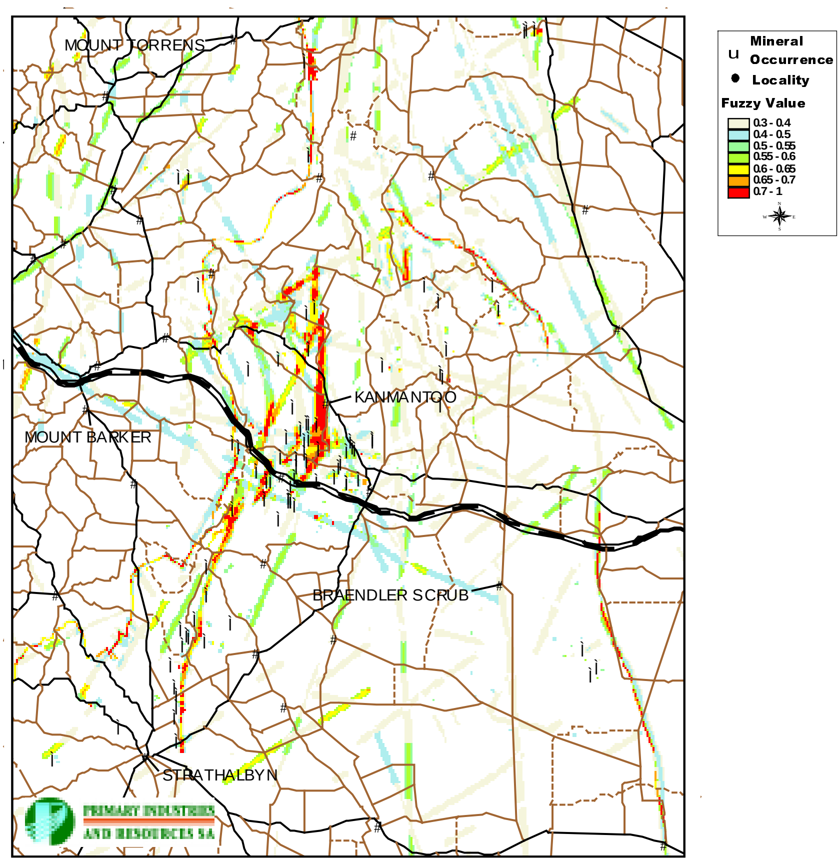

Figure 6. Fuzzy logic results for SEDEX model in study area (100m grid).

Conclusions
We have found that the WOE method of map analysis is useful in several ways for the presentation of data to the mineral industry.

- In areas of high density of previous exploration, it helps outline which areas are relatively more prospective than others.
- Where large and detailed datasets are available, it helps determine subtle associations that are not readily apparent with other methods of data analysis used by exploration geologists.

- The process of compilation of datasets itself has proven to be useful in further understanding the geology.

The fuzzy logic analysis method is useful in other ways.

- It is excellent for locating areas of prospectivity outside regions that have been thoroughly explored in the past.
- It has very good correlation with known mineralisation.
- Fuzzy logic values are readily altered to accommodate new models or variations in current models.
- It is useful in examining the potential of areas for associated styles of mineralisation, which may not yet have been identified (eg. MVT mineralisation related to basinal fluid migration).
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The process has also been very useful in locating gaps in the current database. In the study area we have no regional scale digital geochemistry, just rockchips focused on known anomalies. Detailed regional stream sediment was conducted in the 1970's, but has not been entered into the database. This will be done in the near future and incorporated into the Kanmantoo Province GIS dataset (Burtt et al 1997) for the area.

The next step in this project will be to produce several fuzzy logic models based on the various other mineralisation models described above. The area covered by the modelling will then be extended to cover the mainland outcrop regions of the Kanmantoo Group on the Adelaide and Barker 1:250 000 map sheets. Exploration companies holding the various exploration licences in the area, will then be encouraged to test the most promising targets produced by this modelling with geochemical sampling.

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Application of GIS to sustainable catchment & land resource management

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Abstract
ARCVIEW and SPATIAL ANALYST were used to analyse a range of land attributes and soil degradation of selected areas within the Central West of NSW. The study areas were grouped into five relatively homogenous geologies: namely granite, basalt, other igneous rocks, sedimentary rocks and metasediment, and alluvial deposits. These geologies were used as a basis to intersect with soil landscapes, land capability, soil erosion, land use and slope. The various categories for each of the above land attributes within the different geologies were analysed and described both spatially and quantitatively.

The study results supported the hypothesis by showing a consistent relationship between geology and the other land attributes. For example, granite country is characterised by relatively infertile siliceous sands and non-calcic brown soils; a high incidence of sheet and gully erosion; dominantly grazing land use; land capability categories VI-V; and, slope of less than 20% occurring over 90% of the area. In contrast, basalt country predominantly shows fertile Krasnozem soils; insignificant incidences of soil erosion; the highest level of intensive agricultural practices; dominant land capability categories I-III, and slopes mainly below 10%.

The study has shown GIS to be an invaluable tool for assessing the complex behaviour and interaction of the biophysical factors and processes, which are fundamental to sustainable planning and management of catchment and land resources.

Introduction
This paper presents the result of recent research to demonstrate an innovative approach to using GIS in sustainable land resource management. The paper examines the hypothesis that geology is the primary causal factor controlling the characteristics and constraints of the biophysical system and subsequent land degradation. In other words the geological and geomorphic characteristics of a given area, within a relatively homogenous climatic conditions, are the most critical factors in determining the inherent properties of other land attributes. Consequently, a proper grasp of geology is essential for determining the most appropriate land use and development, predicting potential and magnitude of land degradation and selecting the most appropriate remediation and management practices. Within this geoscientific context, GIS technology was tested in terms of its value to facilitate undertaking effective planning and sustainable management of natural resources.

Methods
ARCVIEW and SPATIAL ANALYST were used to analyse a range of land attributes and soil degradation of selected areas within the Central West of NSW. Using the 1:100,000 geological maps of the Orange-Bathurst area, the study area was subdivided into the following four categories, each with a relatively homogeneous geology:

- Quaternary alluvium deposits
- Tertiary volcanics (basalt)
- Carboniferous granite and granodiorite

- Ordovician-Devonian metasediments (marine sedimentary and volcanic rocks that were subjected to a low-medium grade regional metamorphism).

GIS was used to manipulate and analyse digital data of the study area in order to determine the influence of geology on soil, erosion, land use, land capability and slope. The area selected, approximately 3755 km^2, has relatively uniform climatic conditions, with an annual rainfall of about 650-820 mm, multiple land use systems and varied land resource features.

Results

The study results showed that basalt was the best geology, within the study area, in terms of soil type, land capability, agricultural land use and erosion. The basalt country is most intensively used for agriculture. Cropping and horticulture in this geology account for more than 80% of all intensive agricultural activities in the study area. On the other hand, area covered with metasediments was the worst in terms of the above land attributes. For example, shallow and infertile soils occupy 76% of the area. The land use in this category is predominantly pasture (78%) and uncleared land (18.5%) whereas intensive agriculture presents in less than 2.5% of the area.

Good soils in the granite region present in approximately 40% of the area whereas fair to poor soils occupy up to 60 %. The predominant land use in the granite division is pasture (91%); while cropping and horticulture fall below 3%. Granite country was the most degraded region where sheet erosion and gully erosion were evident in 37% and 47% of the area. The high erosion level in this geology is due to the relative enrichment of sodium in the granitic soil which is a primary cause for producing dispersing and unstable soil.

Soils associated with the alluvium are ranked second to those of basalt origin. Good quality soils account for 56% and fair soils form 36% of the study area. The unexpected low percentage of good soils in this geology is believed due to the fact that most of the alluvial deposits were originally derived from the granite and granodiorite country. Subsequently, the inherent limitations of those rocks were reflected, to some extent, on the alluvial soils. Despite these limitations, the alluvial area is the second best in terms of agricultural pursuits and land capability. Quaternary alluvium shows insignificant sheet erosion (<2.5%) but about 15% gully erosion.

Conclusion

The results support the hypothesis by demonstrating that geology in the study area was the paramount factor influencing the inherent properties of the biophysical factors and subsequently the land use and development. The resilience of a given land in terms of its geological properties is far more critical than the type of land use or anthropogenic activities in relation to land degradation and sustainable management of resources. Furthermore, the study has shown that GIS is an invaluable tool for assessing the complex behaviour and interaction of the biophysical factors and processes which are fundamental to sustainable catchment and land resource management.

AGSO's ArcView extension helps define the outer limit of Australia's marine jurisdiction

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The resource jurisdiction of a coastal State such as Australia extends beyond its land territory and throughout its adjacent continental margin. In the areas between adjacent countries, the limit of jurisdiction is subject to negotiations based on international conventions and principles of customary international law, whereas in areas facing open ocean and the international community, it is subject to rules set out in the 1982 United Nations Convention on the Law of the Sea (UNCLOS). The entry into force of UNCLOS on 16 November 1994 was an important milestone for Australia because it provided new rules for defining its vast marine zones, as well as setting out rights and obligations for managing the environment and resources within them.

There are nine areas around Australia where seabed jurisdiction could be extended beyond the 200 nautical mile Exclusive Economic Zone (EEZ) providing Australia justifies the claim defining their outer limits according to the terms set out in Article 76 of UNCLOS by the 2004 deadline. Once the claim is accepted these areas will become part of Australia's "legal" Continental Shelf (CS). The data supporting the claim includes information on the morphology, sediment thickness distribution and bathymetry of the margin and adjacent sea floor. During the last four years AGSO has been conducting surveys over the margins of Australia collecting new data, as well as assembling existing data, relevant to the claim. Large volumes of diverse digital data required systematic handling and processing. Over the past two years AGSO's Law of the Sea project has been developing new strategies for constructing digital databases supporting Australia's claim for the CS, as well as tools enabling simple and effective access to the data.

The new "Law of the Sea" ArcView extension has a series of tools to load the data, create bathymetric gravity and magnetic profiles and to analyse them. Specialised tools include analysis of the change in gradient, automatic selection of the sediment thickness points, defining critical points for the 2500 m contour, and creation of stacked bathymetric profiles and more. Projects created with the help of the extension represent an integrated system where profile and map views are interactively linked, and each point in the database can be queried from the map and/or a profile. Critical seismic sections are linked to their corresponding bathymetric profiles. General survey information can be accessed through the OZMAR ORACLE database, which enables queries to be made on the geophysical data and navigational systems available.

The new Law of the Sea extension is easy to load and use, and could be as a more generic tool. Its ability to view survey data in either plan or profile view, and link it to a variety of other spatial information, makes it an attractive tool in any geological interpretation project based on geophysical survey data.

Australia's maritime boundaries

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Abstract

Under the United Nations Convention on the Law of the Sea (UNCLOS) Australia is entitled to claim an area in excess of 11 million square kilometres. Australia's rights within this area vary according to different maritime zones as described in the convention. The Australian Surveying and Land Information Group (AUSLIG) is working with the Australian Geological Survey Organisation (AGSO) and others to define these boundaries and comply with UNCLOS requirements.

The location of maritime zone boundaries is particularly significant to geoscience industries involved in offshore exploration. AUSLIG is developing the Australian Maritime Boundaries Information System (AMBIS) as a GIS database for all information related to the position of Australia's maritime boundaries. This paper describes the different maritime boundaries, how they are being defined, and their importance to Australia and the geoscience industry. It also describes the AMBIS data.

Introduction

A 1988 cabinet decision assigned the Australian Surveying and Land Information Group (AUSLIG) with the responsibility of determining Australia's maritime boundaries and providing related advice to government. This charter was reaffirmed in the 1996 budget. The recent restructure of AUSLIG led to the establishment of AUSLIG's Maritime Boundaries Program.

This paper briefly describes the tasks and challenges involved in the establishment of the Australian Maritime Boundaries Information System (AMBIS) and the data held within it. This data will form part of the Australian Spatial Data Infrastructure.

What are maritime boundaries?

In late 1994, Australia ratified the United Nations Convention on the Law of the Sea (UNCLOS) and the convention officially came into force in November 1994. UNCLOS is a very significant agreement providing international conditions and limits concerning the use and exploitation of the earth's oceans. Included in UNCLOS are rules on how member States (countries) define their maritime jurisdictional boundaries.

Under UNCLOS there are a number of maritime zones defined by their distance from the land, or more precisely, the Territorial Sea Baseline (TSB). Australia's maritime zones are:-

- Territorial Sea (0-12 nautical miles). Australia has almost full rights although must allow innocent passage.
- Contiguous Zone (12-24 nautical miles). Australia may exercise control to prevent or punish infringements of customs, fiscal or sanitary regulations.
- Exclusive Economic Zone (EEZ) (12-200 nautical miles). Australia has the right to explore and exploit sea bed and water column.

- Continental Shelf (12-350 nautical miles). UNCLOS allows for a country to claim seabed rights on continental shelf areas to a limit (usually 350 nautical miles from the TSB) where a physical continental shelf exists beyond 200 nautical miles.

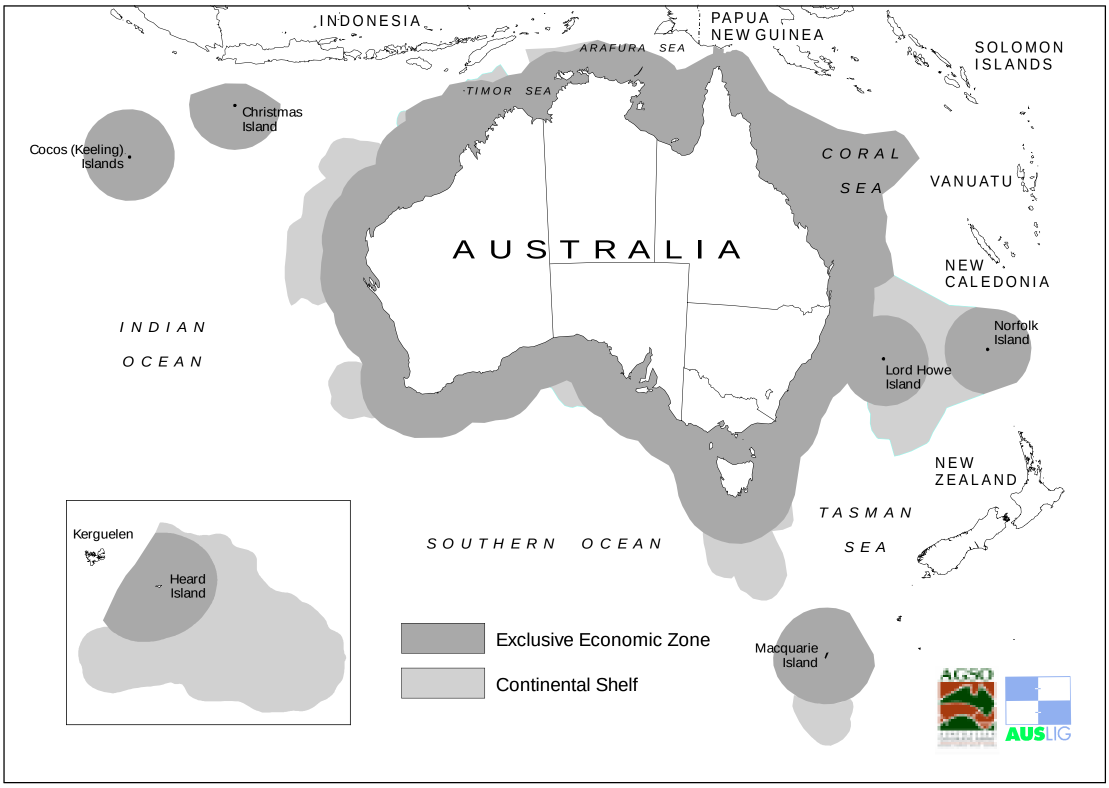
Nautical Miles

Figure 1. Maritime zones

Other zones relevant to Australian legislation are:

- Coastal Waters (from the constitutional limits of the States and the Northern Territory to 3 nautical miles from the TSB). States and the Northern Territory have certain jurisdictional rights [This zone was agreed in the 1980 Offshore Constitutional Settlement and is defined in Coastal Waters legislation].
- Australian Fishing Zone (3-200 nautical miles). In most cases, the outer limit of this zone is identical to the EEZ boundary. (Defined by Fisheries Management Act 1991 (FMA) including the amendments to that Act made by the Maritime Legislation Amendment Act 1994.)

Figure 2. Australia's EEZ and Continental Shelf Areas (Preliminary).



Extended continental shelf claim

For Australia to claim areas of extended continental shelf beyond 200 nautical miles, a claim must be submitted to the UN Commission on the Limits of the Continental Shelf by November 2004. The approximate area Australia is entitled to claim is shown on Figure 2. The determination of the physical limits of the continental shelf is the responsibility of the Australian Geological Survey Organisation (AGSO).

AUSLIG'S maritime boundaries data

AUSLIG currently has preliminary data available for all of the boundaries of the zones described above. This data is based largely on the original unvalidated territorial sea baseline with the jurisdictional boundaries being computed using an ArcInfo buffering routine.

More reliable and accurate data is planned to be available from the end of 1999. This new data will be based on spheroidal computations rather than less rigorous algorithms which work on data transformed to a flat projection. The actual spheroidal calculations are complex and require the development of specialised software. The development of the software is being performed by the University of Melbourne's Department of Geomatics under tender to AUSLIG. The specifications are based on the UNCLOS requirements and restrictions.

Urgent projects requiring accurate boundary determination should be referred to AUSLIG's Maritime Boundaries Program. In most cases we can provide recomputed boundaries over local areas using the latest and most accurate data.

There is a steadily increasing demand for information on Australia's maritime boundaries. As well as marine exploration, the data has been used for applications such as native title claims, Customs, fisheries and environmental applications.

Cooperative Project

The Maritime Boundaries Program relies on the continued support of the State and Territory governments and a number of Commonwealth Government agencies.

The state and territory mapping agencies supply the Maritime Boundaries Program with coastline mapping data, and other information, to assist in the determination of the TSB. Commonwealth agencies assist as follows:

- Australian Hydrographic Office provides digital charting information, bathymetric surveys of critical areas, Laser Airborne Depth Sounding (LADS) data and charting advice and assistance.
- The Australian Geological Survey Organisation (AGSO) provides information on the determination of Australia's continental shelf.
- The Attorney General's Department provides advice on national and international law and assistance with international treaty negotiations.
- The Department of Foreign Affairs and Trade provides guidance on diplomatic and United Nations issues and also has the lead role in international treaty negotiations.

Related laws and conventions

UNCLOS provides the framework for the Maritime Boundaries Program work. Also relevant are a number of Australian Acts including the Seas and Submerged Lands Act (1973) and the Petroleum and Submerged Lands Act (1967). The Offshore Constitutional Settlement (1980) is also relevant.

Defining the territorial sea baseline (tsb)

Critical to the determination of all maritime boundaries is the determination of the TSB around Australia and its offshore international territories. Essentially, the TSB is the line of Lowest Astronomical Tide (LAT) however UNCLOS allows for the TSB to jump across bays (bay closing lines) and rivers (river closing lines) and between islands and along heavily indented areas of coastline (straight baselines) under certain circumstances.

The TSB was originally determined in the early 1970s by AUSLIG's predecessor (Natmap) based on small scale mapping supported by some aerial photography. The Maritime Boundaries Program is now validating this data and carefully attributing the data quality, including lineage (history), to create a comprehensive GIS database known as the Australian Maritime Boundaries Information System, AMBIS.

Determining lowest astronomical tide (LAT)

Article 5 of UNCLOS defines the baseline as “the low-water line along the coast as marked on large scale charts officially recognised by the coastal State”. “Low-water” is not more clearly defined and Australia has elected to use the Lowest Astronomical Tide (LAT) as this is the datum used on hydrographic charts. The use of lowest astronomical tide also maximises the area Australia can claim under UNCLOS.

Hydrographic charts are primarily concerned with navigational hazards and water depth but not specifically the line of lowest astronomical tide. Topographic mapping typically defines the coastline as the line of high tide (usually mean high water). Accurate determination of lowest astronomical tide can, therefore, present some difficulties, particularly in areas of large tide range and gradually sloping foreshores. Such areas are common in the north of Australia and some of these areas are also largely uncharted.

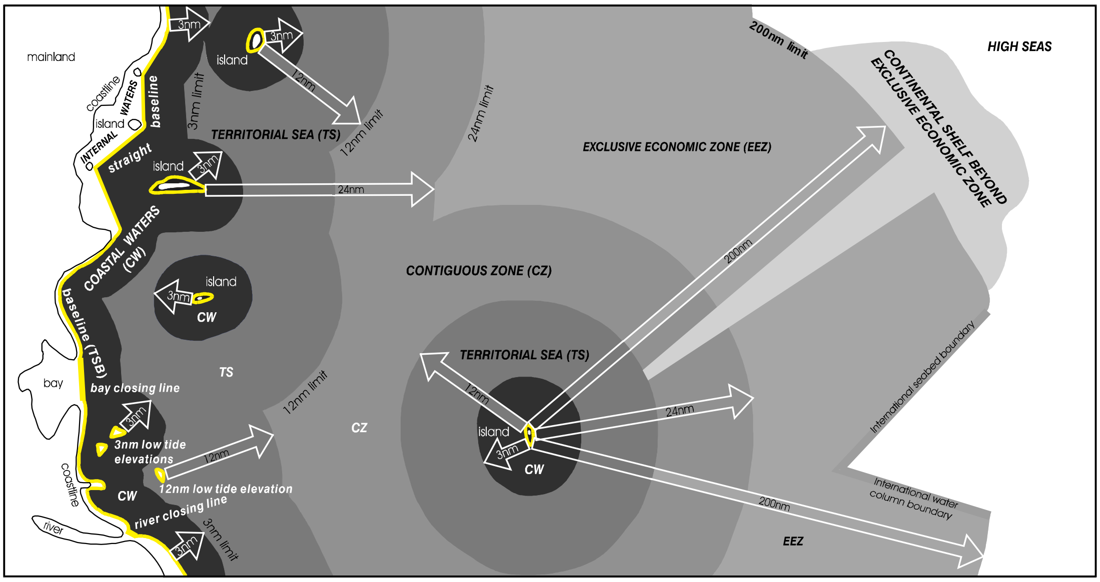


Figure 3. Relationship of maritime features, limits and zones seaward of the territorial sea baseline. (Not to scale)

Some additional complexities

Co-ordinate datum

Current data is available in both AGD66 and GDA (WGS84[1]) datum. The use of AGD for remote offshore areas is theoretically invalid and, if used for international negotiations, raises the issue of transformation parameters. This issue has arisen in the negotiations with Indonesia and has resulted in some of the original 1971 boundaries defined in AGD66 and the newer 1997 boundaries expressed in WGS84.

Antarctic boundaries

At the time of writing no firm decision has been made regarding whether or not Australia will submit a claim for extended continental shelf areas off our Antarctic Territories. Defining the TSB in Antarctica will be a significant task and preliminary investigations suggest that the use of Synthetic Aperture Radar (SAR) may be of great assistance. The problem is made more complex by uncertainty as to whether the grounding line, the limit of the continental ice shelf, or the limit of permanent sea ice should be used to determine the TSB.

AMBIS

As previously mentioned, the Maritime Boundaries Program is establishing all the necessary data into a GIS system known as AMBIS, the Australian Maritime Boundaries Information System. The original AMBIS database was developed in GEOVISION however this is now being migrated into ARCINFO. This migration process is being used to fully validate the data and ensure that all features carry the relevant attributes. The size and complexity of the database makes this a significant task which is not due for completion until the end of 1999.

Database structure

AMBIS is a vector Geographic Information System. The coverages can be classified into three groups as follows:

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[1] Note that the difference between GDA and WGS84 is approximately 10cm which is insignificant in regard to maritime boundaries.

1. Major coverages are those that directly relate to the determination of the Territorial Sea Baseline and the Zone boundaries determined from it.
2. Related coverages are other maritime boundaries which are stored in AMBIS as required.
3. Reference coverages show the extent of different types of data used in the determination of the Territorial Sea Baseline.

Figure 4. AMBIS major coverages

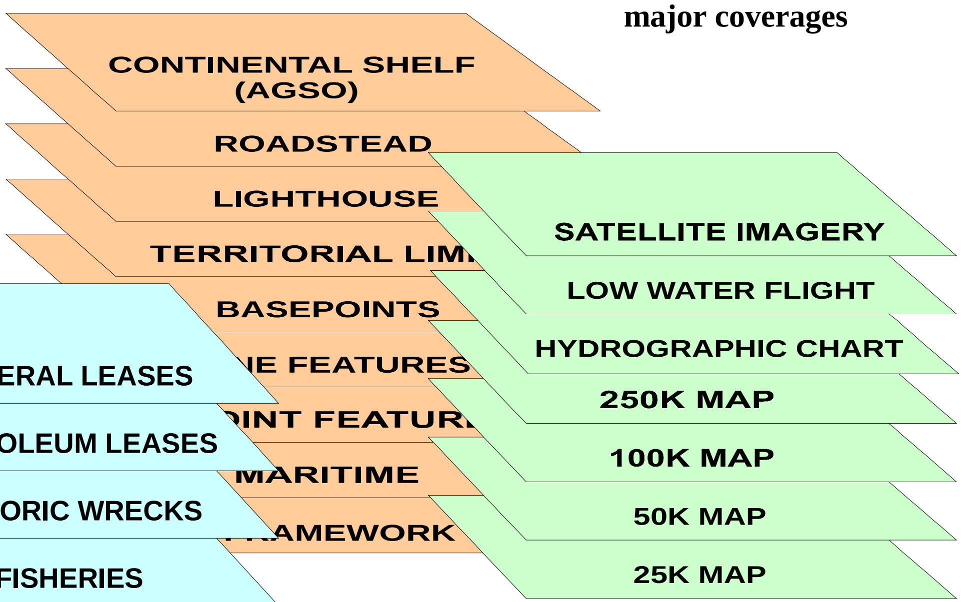

Figure 5. AMBIS related coverages

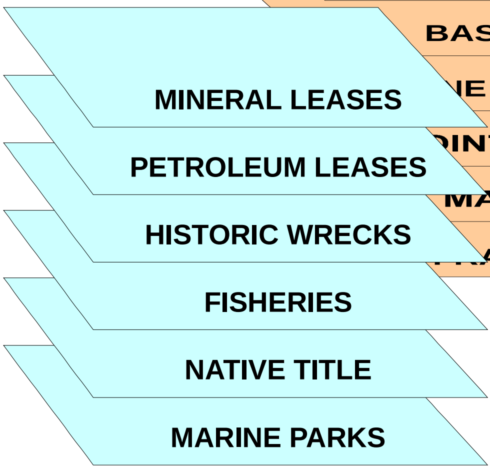

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Figure 6. AMBIS reference coverages

Quality information

Comprehensive attributes are linked to each feature. In particular, it is necessary that detailed quality information on all data used to define the Zone Boundaries is recorded. Attribute information stored in AMBIS includes:

- Source of the data (map, coordinate, remote sensing, aerial photograph, etc.)
- Details of source material (name and number of map, scale, source agency, etc.)
- Accuracy (estimated planimetric accuracy, or other, were available)
- Datum (horizontal and vertical)
- Data capture methods (screen digitising, stereograph etc.)
- Details on data capture (transformations used, number of control points, residuals, digitising agency, etc.)

Conclusion

The United Nations Convention on the Law of the Sea (UNCLOS) provides a vital basis for international cooperation and provides essential guidelines for boundary determination. Protecting Australia's interests over the vast area to which we have a legitimate claim requires careful application of these guidelines. Complexities arise in the definition of the territorial sea baseline, the limits of the continental shelf, and in the rigorous computation of the various jurisdictional limits. The development of AMBIS is a vital component in the management of Australia's Maritime Boundaries.

Provisional maritime boundaries data is available from AUSLIG's National Data Centre. Revised data,which has been rigorously computed and fully attributed, will become progressively available from the end of this year with all Australian data available by June 2000.

More information on Australia's Maritime Boundaries can be found through the AUSLIG Web site at http://www.auslig.gov.au/marbound/ambis.htm

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The Australian Spatial Data Infrastructure (ASDI) and the Geocentric Datum of Australia (GDA)

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Abstract

An Australian Spatial Data Infrastructure (ASDI) aims to ensure that c*urrent and accurate geospatial information will be readily available to contribute to both local and national economic and social development, and informed environmental management.*

The ASDI will provide the strategic directions for furthering the focussed implementation of freely available common on-line data management tools, the inter-agency agreements required to establish a distributed series of Nodes and the establishment of responsible agencies for clearly defined fundamental datasets.

AUSLIG is the responsible agency for the management and implementation of the ASDI on behalf of the Commonwealth and has developed a draft ASDI implementation strategy. This draft was completed in late 1998 in preparation for further consultation with stakeholders from all jurisdictions and industry. The aim of these consultations are to further co-align the ASDI with the existing Commonwealth and State/Territory SDI implementation initiatives. Industry groups too are being involved as a priority, as one of the main aims of the ASDI is to further build an Australian spatial data industry.

Many of the underlying principles of the ASDI have previously been defined by both the Australia New Zealand Land Information Council (ANZLIC) and the Commonwealth Spatial Data Committee (CSDC). The *draft* ASDI Implementation Strategy attempts to further crystallise these views in terms of a specific work program phased over the next few years. The underlying principles, projected milestones and suggested timings for the implementation of the ASDI over several clearly defined phases are outlined in the draft plan.

The specific ASDI technical goal is to establish an *ASDI Spatial Data Clearinghouse* using common standards and software modules that are developed in an incremental way. The perceived essential precursors to further ASDI module implementation include: a distributed on-line metadata directory (the Australian Spatial Data Directory has already been released); a clear definition of fundamental datasets; an awareness of, and involvement in, the ISO TC211 and Open GIS activities; and the early adoption of the Geocentric Datum of Australia (GDA).

GDA results from an international trend to adopt a geocentric datum. The move will make mapping and spatial data coordinates compatible with satellite based coordinates, providing a single reference framework for collecting, storing and applying spatial data at local, national and international levels.

The Intergovernmental Committee on Surveying and Mapping (ICSM) has adopted the GDA, which will be progressively implemented Australia wide.

Introduction

The ASDI will provide better access to essential geographic information of Australia to government, the private sector and the broader community. This increased accessibility is necessary to improve decision-making in such areas as environmental assessment, natural resources management, socio-economic studies and physical infrastructure development such as mobile communications networks, roads, railways, power grids and airports.

Australia's national mapping agency, AUSLIG, is the focal point at federal level for the development and implementation of the ASDI.

AUSLIG is the Commonwealth Government's primary source of advice on spatial information matters. Its role is to ensure that fundamental spatial information is available for the benefit of both Australian and international communities.

It is recognised that no single organisation can build the ASDI and that a collaborative effort is essential to its success. The Commonwealth Spatial Data Committee, a forum of Commonwealth agencies with interests in land information issues, serves an important coordination role at Commonwealth level in this regard.

Australia's peak forum on land information matters, the Australia New Zealand Land Information Council ensures effective collaboration between Commonwealth, State and Territory governments.

AUSLIG has now developed a draft ASDI implementation strategy. This draft was completed in late 1998 in preparation for further consultation with data/information managers from all jurisdictions and industry.

This paper will outline key elements of the draft ASDI implementation strategy and provide further information on a number of initiatives which have recently been announced.

ASDI recurrent themes

The ASDI has a number of recurrent themes that apply. These themes need to be considered when specific projects or initiatives are being developed. The recurrent themes include:

- Interoperability;
- Building partnerships;
- Identification and use of recognised standards;
- Leveraging technology;
- Utilizing public domain software where possible for the basic ASDI building blocks. Commercial software is also appropriate where it is compatible and uses open standards;
- Recognising the principle that databases will be maintained by a recognised custodian/ responsible agencies;
- The ASDI clearinghouse should adopt a *distributed database model* where custodians manage their own data;
- The ASDI should be compatible where possible with the emerging Global Spatial Data Infrastructure (GSDI).

Current ASDI initiatives

The ASDI Implementation Plan contains a number if discrete but inter-related elements. The key elements of the plan are described in more detail below. It is envisaged that the detailed implementation plan will be available after CSDC endorsement in the near future.

1. Alignment of ASDI and NLWRA activities

The NLWRA has been established by the Commonwealth as a program of the Natural Heritage Trust. The purpose of the NLWRA is to provide an independent, comprehensive nationwide appraisal of Australia's natural resources. It is due to complete its term in June 2001.

According to an Industry Commission statement published in September 1997 much of the data collected in Australia relating to the physical condition of natural resources lacks comparability and uniformity. Lack of comparability means no meaningful comparison is possible between different land management practices and this significantly reduces the usefulness of the information collected.

The Audit has indicated its strong support of the ASDI. An effective ASDI will greatly assist the Audit in developing a national information system for land, water and vegetation data that will continue after the Audit's operations cease in June 2001.

The Audit's Framework Database and Atlas projects closely parallel the Fundamental Datasets and Distribution Network components of the ASDI program and the ASDD. The Audit and AUSLIG have developed an MOU to harmonise work programs and provide efficiencies to each party and avoid unnecessary duplication of effort as well as providing a coordinated approach to the State and Territory governments. *Stage 1* of the Audit's Atlas project involves establishing Commonwealth nodes of the Atlas and is due for completion in June 1999. *Stage 2* is being developed to extend the on-line mapping nodes to the State and Territory Jurisdictions.

Other data access, on-line mapping software (node) development and data management agreements have already been put into place by the Audit. The Audit process (combined with the Australian Coastal Atlas Project, being led by Environment Australia) should therefore assist with:

- definition of *fundamental* datasets;
- provide the road map for implementing a series of distributed nodes;
- identify shortcomings of, and improvements in, the ASDI Implementation Plan.

2. A concept architecture for the ASDI clearinghouse

Many agencies and jurisdictions are in the initial stages of developing on line services. An objective of the ASDI is to ensure that there is a high degree of standardisation so that user's have access to comparable data held by various custodians.

In order to promote consistency of the various Clearinghouse implementations being developed in various jurisdictions and to be provide a blueprint for a Commonwealth implementation over the short and medium terms, AUSLIG has commissioned the CSIRO Centre for Mathematical and Information Sciences to develop a concept architecture for the ASDI clearinghouse.

The consultancy will:

- Identify best practice for SDI Clearinghouses based on a review of online data access services being developed by Commonwealth, State and Territory governments and by the Federal Geographic Data Committee (FGDC) and the Open GIS Consortium in the United States;
- Specify a modular approach that can be progressively implemented for the Clearinghouse including identifying the standards, technologies and protocols recommended for each module;

It is envisaged that modules will incorporate the following functionality:

Exploring - discovery

- Metadata distributed via linked Z39.50 Jurisdictional & Thematic directories/ servers i.e. The Australian Spatial Data Directory *http://www.environment.gov.au/net/asdd/*
- Stand alone image and browse graphics embedded into the metadata records.

Data download & e-commerce

- Customised data retrieval and download facilities, incorporating on-line licensing;
- Data transfer on-line via the options of several formats and several permission levels (including on-line data licensing) from the directories (e.g. The QLD Data Exchange Web (DEW) System);
- E-commerce tool for agencies who have to undertake cost-recovery.

Online MAPPING

- Interactive mapping serving images and vectors on the fly (online mapping e.g. Environment Australia Australian Coastal Atlas and National Pollutant Inventory solutions, NSW ICMISS, ACTMAP online, Victorian GIConnections);
- Automatic layer/scale selection and service thresholds;
- Map symbolisation and on-line cartographic standards for rendering;
- Linking the metadata directories to the on-line mapping tools;
- Links to documents and textual information from both the metadata and the on-line maps;
- Thesaurus and gazetteer function;
- Feature query and attribute retrieval;
- Customised front-ends pending user access level requirements/ profiles;
- Visualisation tools suites;
- Real - time incorporation of spatial data from the Clearinghouse directly into the client's GIS software/ project.

CSIRO will conduct meetings with key spatial data Clearinghouse developers and stakeholders as identified by AUSLIG. The following groups will be included in the consultation: ERIN; AGSO; BRS; ABS; Murray Darling River Commission, ICMIS (NSW), InfoShop (SA), OpenGIS Consortium.

It is anticipated that a report will be available in June 1999.

3. Australian Spatial Data Directory

The Australian Spatial Data Directory (ASDD) will be supported as a major ASDI activity again in 1999. The ASDD is considered the cornerstone of the ASDI Spatial Data Clearinghouse. The ASDD was officially launched in November 1998 at the GSDI Conference in Canberra. 20,000 metadata entries now exist from approximately 14 nodes to the directory. An “incubator node” is still being maintained by the Bureau of Rural Sciences (BRS) on behalf of those agencies who as yet do not have the skills and/or resources to house their own node.

A continuing feature will be the close integration of ANZLIC Metadata Working Group (AMWG) and ASDD National Coordination Group. The ASDD National Coordination Group (AUSLIG, ERIN & BRS) are operating a three part “ASDD Implementation” Consultancy in 1999 to assist State and Territory jurisdictions to develop their own ASDD node. The skills and knowledge to establish agency *stand-alone* node will be made available to all the CSDC member agencies.

There will be efforts in 1999 to increase the amount and the quality of Commonwealth metadata held on the ASDD, both through the BRS incubator node and also through agency stand-alone nodes. Efforts will also be made to build the thematic Marine and Coastal Data Directory of Australia (Blue Pages) into the ASDD while retaining its unique identity.

Moves towards the updating of the “ANZLIC Metadata Guidelines” by the AMWG will be supported, as will the overall push towards the adoption of the ISO TC211-15 Metadata Standard.

4. The Australian OpenGIS WWW mapping consortium

The definition of the term *Clearinghouse* has historically remained ambiguous, however the overall premise is that the user can enter the ASDI Spatial Data Clearinghouse *for Enquiry, Search, Discovery, Viewing, Visualisation & Retrieval* of spatial data.

Web Mapping is included in the ASDI Clearinghouse definition to assist with data viewing and visualisation. It provides users with the ability to gain a better understanding of the data before needing to purchase it.

AUSLIG has established a consortium, comprising 24 industry groups and Government agencies to work in partnership with the main international driver on web mapping, the US-based Open GIS Consortium (OGC). The partnership with OGC gives Australian Consortium members a range of benefits, including the opportunity to provide direct input on user requirements and the technical development of web mapping at an international level.

Membership of the OGC will ensure Australia's involvement in the development and testing of a new international specification for web mapping. Although web mapping is already possible in Australia, the implementation of an international standard will allow the integration of existing web mapping systems and vastly improve access to distributed datasets by a wider range of users.

As a test site for the specification, Australian industry groups will have early warning of emerging technologies required to meet the standard, giving them a competitive advantage in their strategic planning during a time of rapid technological change.

5. ASDI partnerships program

One of the imperatives in the development of the Australian Spatial Data Infrastructure is opening up access to data that is currently not well publicised. It is also to develop some practical projects that can be undertaken to improve the knowledge of and benefits of the ASDI.

The *ASDI Partnerships Program* has been instigated by AUSLIG this year.

The main aim of the 1999 ASDI Partnerships Program is the outreach to agencies and agency groupings to assist their building accurate, accessible and timely spatial data information holdings utilising existing data and coordination mechanisms. Groups could include:

- Industry Groups;
- University consortia;
- CRC's;
- Industry R&D Programs;
- R&D Corporations;
- Local Government Groupings

A strong interface with a relevant government authority is also desirable.

Main goals of the 1999 ASDI Partnerships program

The goals of the ASDI Partnerships program include:

- Increasing the overall awareness and understanding of the vision, concepts, and benefits of the ASDI;
- Developing common inter-operable solutions for discovery, access and use of geospatial data in response to industry, environmental and socio-cultural needs;
- Using consortia and partnership-based approaches to develop and maintain common collections of geospatial data for informed decision making;
- Building relationships between organisations from all spheres of government, non government authorities and industry sectors to support the continuing development of the ASDI;
- Assisting AUSLIG with developing both the business and guiding principles of the ASDI.

6. ASDI compliance testing

During 1998, ANZLIC developed a draft Compliance model for use in the evaluation of datasets to determine if they can be deemed "ASDI Compliant". CSDC has since taken this model, enhanced it and used it to evaluate 6 Commonwealth Datasets as a pilot project. The compliance testing pilot has proved to be a valuable tool in the standardisation of fundamental data management. Compliance audit teams consist of a representative from the data custodian agency, a subject matter specialist and an audit consistency representative to ensure that audits are undertaken to a similar standard.

The draft compliance model used in the evaluation to date is given below. In this case ACRES TM data has been evaluated.

ASDI compliance rating

To be ASDI compliant, the dataset must be rated as compliant against each of the 7 criteria. The ratings used are either:

Not yet compliant—the dataset does not yet comply with this criteria

Compliant—the dataset complies with criteria.

Data description

Dataset	*Title*	*LANDSAT Thematic Mapper data.*
	Custodian	Australian Surveying and Land Information Group (AUSLIG)
	Jurisdiction	Australia
Description	Abstract	The LANDSAT satellites are polar orbiting remote sensing satellites that capture the synoptic views of earth surface from an altitude of 705 km, once in every 16 days. LANDSAT 5 launched in 1984, carries a high spatial resolution (30m) sensor called Thematic Mapper (TM) which records data in 7 spectral bands covering visible, near infrared, short wave infrared and thermal infrared regions of the electromagnetic spectrum. A full scene TM imagery covers an area of about 185 kilometers by 172 kilometers. ACRES has been archiving this data from September 1987 onwards.
	Geographic extent	Australia

Compliance assessment

Element	*Details*	*Rating*
1. Format	Digital, raster data in archive format. (This is an industry standard for raw data)	C
2. Metadata	Complete & meaningful metadata for all ANZLIC page 0 elements is available on ASDD. Metadata meets ANZLIC requirements and contains some additional Page 1 information. Resolution is included.	C
3. Standards	Processed TM data sets are provided in the industry standard formats (CCRS format, EOSAT fast format) and can be read by the majority of the IP software packages. Comprehensive technical documentation on data formats is available on ACRES web site. Processed data sets (level 10) are GDA compliant.	C
4. Content/ Extent	Repetitive coverage of entire Australia is available.	C
5. Access arrangements	Well developed distribution arrangements in place for accessing data. Conditions of use and pricing, licensing policies are well documented (price lists and data characteristics brochures viewed at audit). Have standard data transfer formats which are accepted by most of the vendor software packages.	C
6. Custodian	Australian Surveying and Land Information Group (AUSLIG)	C
7. Quality Assurance	ACRES is quality accredited under AS/NZS ISO 9002. Well defined QA system is in place and all the processed products go through a QA check before they are sent to the customer. QA documentation and certification viewed at audit.	C

Summary comments and recommendations
This data set fully complies against each criterion.

Compliance Result
The LANDSAT Thematic Mapper dataset is/ ~~is not yet~~ ASDI compliant

Geocentric datum of Australia

The establishment of the GDA is another cornerstone of the Australian Spatial Data Infrastructure. The GDA will provide a single reference framework for collecting, storing and applying spatial data at local, national and international levels. This single framework facilitates interchange of data between various geographic information applications. GDA provides compatibility with GPS measurements allowing for the direct input of GPS field data into datasets from other GPS surveys and mapping datasets and geographic information systems produced on a geocentric datum. GDA also eliminates the need for GPS users to have an understanding of datum and transformations and results in more efficient utilisation of resources and reduces overheads.

Before 1966 there were many different astronomically determined datum, mainly using the Clarke 1858 ellipsoid. In 1966 the first National datum was established (the Australian Geodetic Datum - AGD), using the Australian National Spheroid (ANS) and Johnston Geodetic station as the origin. This origin was still essentially astronomically determined. AGD was a best fit of the Australian region, with its centre offset from the earth's centre of mass. This was not only adequate for Australia; it was undoubtedly the best approach at the time. Geodetic coordinates on this system (latitude & longitude) are known as AGD66 coordinates and the Universal Transverse Mercator (UTM) grid coordinates are known as Australian Map Grid 1966 (AMG66) coordinates.

In 1984 additional observations and improved computing techniques were used to upgrade the AGD & AMG coordinates. These are known as AGD84 and AMG84 coordinates, and are still based on the AGD. In 1984, when adopting the AGD84 coordinate set, ICSM recognised that a geocentric datum was always inevitable due to global forces. This was reinforced in 1988 when ICSM recommended that Australia adopt a geocentric datum by 2000. In 1994 a new datum was established - the GDA.

The AGD and GDA are two different mathematical models of the shape of the Earth. Each has a different origin and subsequently a point on the Earth's surface will have different coordinates based on each datum. While features on the ground will not change, coordinates will shift approximately 200m in a north easterly direction, between AGD and GDA. The magnitude and the orientation of the shift can vary across Australia by 10-15 metres and a few degrees respectively.

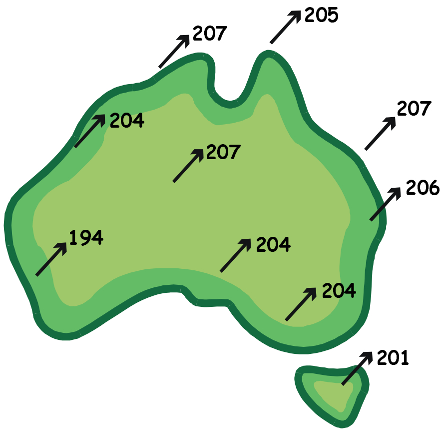

Figure 1. The approximate differences between the AGD & the GDA across Australia.

Coordination of GDA implementation

ICSM activities.

The Intergovernmental Committee on Surveying and Mapping (ICSM) recognises that changing the nations datum is a complex task and assistance will be required in a lot of areas. AUSLIG provides both an Executive Officer and GDA Promotion Officer to support ICSM. ICSM has focused its activities on the following areas:

> ***Industry Briefings:*** ICSM and other State and Territory representatives will provide briefings to industry at workshops and seminars up to 2000. On average there would be more than one workshop per week around Australia.
>
> ***Educational Material:*** ICSM will be publishing material on a regular basis in popular industry publications and will be encouraging the education industry in Australia to include GDA implementation as part of its education programs.
>
> ICSM has set up a GDA Promotions Working Group. The working group has a representative from each State & Territory of Australia and a representative from New Zealand. The initial task of the Working Group has been to develop an integrated promotion and education campaign between all jurisdictions. Contact Ms Kelley Zammit (email: icsmgda@auslig.gov.au, Ph: 02 6201 4357) if you wish to know more about the GDA Promotions Working Group.
>
> ***Software Development:*** ICSM is encouraging GIS and GPS software companies to incorporate the necessary transformation routines in their products. When purchasing GIS and GPS products, organisations are encouraged to specify that the product must be at least GDA compatible. Likewise we are encouraging vendors to provide users with technical information on how their product complies with GDA.
>
> ***On-line support through the World Wide Web:*** The GDA web site at http://www.anzlic.org.au/icsm/gda/index.htm contains detailed technical information about GDA and implementation issues, links to other jurisdictional sites and a GDA news bulletin and more.
>
> ***GDA Technical Manual:*** The GDA Technical Manual is a valuable reference available on the World Wide Web at *http://www.anzlic.org.au/icsm/gda/index.htm.* The GDA Technical Manual contains computation explanations, transformation parameters and test data. The GDA Technical Manual can be viewed on screen or downloaded. However, revisions made to the documents on the web may be missed if you do not check the web pages regularly. In time, this manual will be produced as Adobe PDF format, for easy downloading and printing.

The national framework for GDA is already in place and processes to transform from the old AGD system to the new GDA are available. GDA products are already being produced.. ICSM is endeavouring to provide information to assist with the transition.

Status of implementation of the GDA

All the Australian States and Territories have GDA implementation strategies and are at various stages. The jurisdictions that have strategic plans on their World Wide Web sites are provided below for your information.

Commonwealth

ARMY and NAVY mapping agencies due to international obligations use WGS84, which is compatible with and can be considered (for most practical purposes) the same as GDA94.

Airservices Australia have already reproduced all aeronautical charts on WGS84 to meet a January 1998 International obligation.

Australian Surveying and Land Information Group (AUSLIG) has prepared and posted its GDA - Draft AUSLIG Implementation Statement on the Internet, at:
http://www.auslig.gov.au/ausgda/gdastrat.htm

Australian Geological Survey Organisation (AGSO):
http://www.agso.gov.au/information/datum98.html

Environment Australia discussion paper for their wider portfolio responsibilities is available at: http://www.environment.gov.au/epcg/erin/gis/gda/gdaed.doc

Australian Capital Territory: The ACT has posted GDA information at
http://www.palm.act.gov.au/news/palm/news5.htm#anchor1325945

New South Wales: The Surveyor-General's Department in NSW has posted GDA information at *http://www.lic.gov.au/gda/*

Northern Territory: The GDA94 will be the primary geodetic datum in use from 1 January 2000. The spatial referencing system of the Northern Territory Land Information System was moved to GDA about a year ago. All base cadastral and large scale topographic mapping is already on GDA. Geographical information systems operated by utilities and land resource agencies are still on AGD66 and plan to GDA.

Queensland: In Queensland, the Department of Natural Resources is committed to adopting GDA by 1 January 2000. It is expected that a large portion of spatial information users will adopt GDA within the following twelve months. The Department is optimistic that all its data sets and a large portion of State Government data sets will be converted to GDA around 1 January 2000.

South Australia: Detailed documentation of the South Australia GDA implementation is on the World Wide Web at: *www.dehaa.sa.gov.au/res_inform/sicom/gda94/index.html*

Victoria: Detailed documentation of the Victorian GDA implementation and lots more is on the at: *http://www.osg.vic.gov.au/gda94.htm*

Western Australia: Detailed documentation of the WA GDA implementation can be found at:
http://www.walis.wa.gov.au/current_walis_projects/index.htm

GDA & the mining sector

The mining sector has spent some time considering how the move to GDA will effect the mining and exploration leases across the country, both onshore and offshore. In the past most onshore leases have been described using even latitude and longitude divisions. With the move to GDA the descriptions will change, no longer being on even latitude and longitude. Each jurisdiction is looking at how to manage the shift with some help from the Australian and New Zealand Minerals and Energy Council (ANZMEC).

Petroleum leases

Onshore: Overall, jurisdictions will have various transitional arrangements, as well as provisions to deal with the gaps and overlaps in leases/titles according to their respective circumstances.

Offshore: Because of the number and duration of offshore petroleum titles (up to many decades), the Commonwealth will continue to use the existing grid relabelled with coordinates generated by GDA94. Most States and the Northern Territory will align their implementation of GDA94 in State and Territory offshore areas with the Commonwealth's position.

Minerals

Onshore: From year 2000, all new onshore minerals titles will conform with the GDA 94 (either by blocks or description of points). Current licences retain existing location, and with some exceptions, be redescribed according to GDA 94. All jurisdictions will have various legislative transitional arrangements, as well as provisions to deal with the gaps and overlaps according to their respective circumstances.

Offshore: There are only a small number of offshore mineral leases in Australia. From year 2000, all new offshore mineral titles be allocated in accordance with the new GDA 94 one minute block numbering system. Current licences retain existing location under legislative transitional provisions and be relabelled accordingly (because of their short life, these expected to disappear fairly quickly).

In particular, in Northern Territory, there are the Mining Act and Petroleum Act which legislate licences, leases and claims for Mineral and Petroleum exploration and extraction. Exploration licences and three forms of petroleum tenure are defined under legislation in terms of blocks or graticular sections of latitude and longitude. Exploration licence blocks are 1 minute x 1 minute and petroleum blocks are 5 minute x 5 minute. The datum is not defined in the legislation. The datum in use at the time the Acts were proclaimed was AGD66 so by default this must be the legal datum.

The Department of Mines and Energy (NT) proposes to adopt GDA for the definition of Exploration licences. Exploration licences are currently issued for five years. Legislation will be amended such that new Exploration licences will be defined in terms of GDA94. The change to GDA will have no major impact on other types of mining tenements. Mineral Leases and Extractive Mineral Leases are part of the cadastral survey system and are thus surveyed in accordance with the Licensed Surveyors Act. Boundaries are defined by marks on the ground and not coordinates. However, there are plans to compute survey accurate GDA coordinates as part of the cadastral coordination program.

Mineral claims and Extractive Mineral Permits are pegged on the ground from a datum post which is referenced to a trig station (ideally) or a prominent topographic feature shown on a map sheet. These surveys are not required to be highly accurate. Boundary locations are recorded on AGD66 topographic map sheets. The shift to GDA will occur as GDA94 sheets replace AGD66 map sheets.

In Western Australia, the Department of Minerals and Energy (DME) have recently adopted a GDA strategy to include the effect of GDA on Petroleum Leases and Mining Tenements, both offshore and onshore. The strategy deals with the two separately as:

1. Mining Tenements are covered by State legislation whereas Petroleum Leases are controlled by State(s) and Commonwealth legislation; and
2. Petroleum Leases are typically held for much longer periods than Mining Tenements

Petroleum Permits defined by 5'x5' graticules will continue to be defined in AGD coordinates after the year 2000. However all plans and graphics of Petroleum Permits will be referenced to GDA94.

All Mining Exploration Leases currently based on 1'x1' graticule refer to AGD84. The DME have proposed that commencing 4th December 2000 all new Mining Licences will be based on a GDA.

The Australian and New Zealand Minerals and Energy Council are investigating the implementation and legislative options within the various jurisdictions, and are preparing a discussion paper.

For more information on the GDA see: http://www.anzlic.org.au/icsm/gda/index.htm

Conclusion

The ASDI clearly offers the potential of making better quality geographic information available. Many current Commonwealth and State Government initiatives are contributing towards the ASDI and a coordinated approach is required to ensure consistency. AUSLIG's support for coordination bodies, development of fundamental data and contribution to the creation of the Australian Spatial Data Directory is providing an impetus for the ASDI development.

The GDA will provide a consistent framework for collecting, storing and applying spatial data at local, national and international levels. While posing some immediate challenges it will have a longer term benefit to Australia.

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