International Mining for Development Centre
Mining for Development: Guide to Australian Practice

Management of Public Geoscience Data

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The **International Mining for Development Centre** has been established to promote more sustainable use of minerals and energy resources in developing nations by assisting governments and civil society organisations though delivery of education and training, fellowships, research and advice. Our focus is on three core themes of Governance and Regulation, Community and Environmental Sustainability, and Operational Effectiveness.

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Introduction

Geoscience data are at the heart of every resource discovery and at the centre of every resource development. Accessing data that has already been acquired by previous explorers is a key to reducing risk in exploration and mining, which are high risk, long term activities. Being able to build on existing data better focuses future efforts towards identifying the earth's natural mineral and energy endowment. Discovery of a profitable resource commonly occurs only after explorers have repeatedly examined a particular parcel of ground.

Australian public geoscience data repositories represent the cumulative efforts of generations of inquiry. Such archives are a strategic tool to address the challenges of meeting our future demands for mineral and energy resources. They provide vital information to decision-makers not only in industry, but also in government and communities, to support natural resources management through the formulation and implementation of public policies in areas such as: resource development, environmental protection, public health and safety, land use, and infrastructure planning. Hence public geoscience data requires careful management, ensuring the data is secure, reliable and readily accessible.

Technology has had a major impact on public information management and dissemination, and continues to do so. To realise the value of geoscience data, however, also requires development of a mindset that 'establishes a community of practice' and a commitment to the ideal that data be freely available for re-use. Government, industry and the research community in Australia support these goals.

Development of mineral and energy resources can be an important driver of economic growth. In Australia, the Commonwealth (Federal), State and Territory governments are responsible for the management of the country's mineral and energy resources.

An active exploration community is required to discover and develop mineral and energy resources, and to maintain or expand the resources sector. Investment in exploration is based on the expected value of an undiscovered resource and is influenced by a number of factors. The most significant are demand and commodity prices, but the geological prospectivity of a province is also critical at a regional level. The higher the perceived chance of discovering an economically viable deposit, the more likely it is that the exploration expenditure will be made.

Australian practices in geoscience data management and dissemination provide a global benchmark

This paper considers the provision and management of public geoscience data in Australia and its role in sustaining the mineral and energy sector. The text principally refers to pre-competitive onshore data, but in most cases the principles discussed apply equally to the offshore context.

Geoscience data support:

- Efficient discovery of a new generation of large low-cost mineral and energy resources,
- Infrastructure development, and,
- Land-use planning.

The paper does not offer a detailed technical discussion, instead considering in more general terms a number of key questions:

What is 'pre-competitive' geoscience data?

Why and how are governments involved in curating and delivering pre-competitive geoscience?

How are strategic directions and national standards set?

What governance frameworks, standards and practices are used to ensure data integrity, data quality and administrative efficiency?

What data management and delivery technologies are used to improve accessibility?

An exploration company's initial decisions to invest are affected by their knowledge of known deposits, applicable exploration models and geological frameworks, the last providing context for exploration models. In Australia, governments have had a long history of acquiring and providing geoscience data. Regional geological mapping of the Australian continent by the states' geological survey organisations (GSOs) has continued for more than 130 years. The maps and information are made available to the public and are an example of 'pre-competitive' geoscience data.

GSOs acquire, develop, maintain and disseminate a wide range of on-shore and off-shore geoscience information. Modern pre-competitive geoscientific data acquisition and provision programs commenced in the early 1990s, with the principal aim of promoting the global attractiveness of prospective regions. The geoscience programs provide comprehensive suites of data describing the bedrock geology for all significant geological provinces. The information promotes awareness of the prospectivity of a region, enhancing the opportunity for resource discovery and ultimately ensuring a sustainable resources sector. There is now an extensive archive of geoscience information that covers most of the highly prospective terranes in Australia. Improving the coverage of a range of key geoscience data and the understanding of the regional geological framework are key government strategies for attraction of exploration investment.

Increasingly, GSOs are also providing geoscience information and knowledge to enable the government and the community to make informed decisions on broader economic, social and environmental management issues. Geoscience expertise contributes to natural resource and climate change policies, and provides key services to assist preparation for and response to natural disasters[1].

Sophisticated information management systems, governance frameworks and standards are essential to deal with the vast volume and diversity of geoscience data that include not only digital databases, but physical collections such as: paper records, maps, images, rocks, minerals, fossils and borehole core and chips. An important element in 'information management' has been technology adoption, which has affected the collection, organisation, analysis and dissemination of knowledge. Australian GSO data management and delivery mechanisms are recognised by domestic and international explorers to be amongst the best in the world. In the 2012/2013 Fraser Institute's mining survey, four of Australia's GSOs ranked in the top ten for their geological databases on the basis of map quality and ease of access to information[2].

BACKGROUND

Australia – a resource-rich nation

Australia is a federation of six states [Western Australia (WA), South Australia (SA), Victoria (Vic), Tasmania (Tas), New South Wales (NSW) and Queensland (Qld)] and two territories [the Northern Territory (NT) and the Australian Capital Territory (ACT)]. There is a central Commonwealth government based in the national capital, Canberra, and separate state and territory governments. The states own and control mineral and petroleum resources within their jurisdictions, which extend to beyond the low water mark for three nautical miles into surrounding territorial seas. Mineral and energy resources in the remaining territorial sea belong to and are controlled by the Commonwealth government[3].

As a resource-rich country, Australia has an impressive inventory of minerals. It contains the world's largest Economic Demonstrated Resources (EDR) of gold, iron ore, lead, rutile, zircon, nickel, silver, uranium and zinc, and the second largest resources of bauxite, brown coal, cobalt, ilmenite and tantalum. Australia's copper and lithium resources are ranked third, thorium is ranked fourth, and black coal and manganese ore resources are ranked fifth in the world[4]. Although Australia has only about 0.3 per cent of the world oil reserves, it does have important gas resources as well as significant unconventional petroleum resources: shale gas, coal seam gas, 'tight' gas and oil shale. Conventional gas and unconventional petroleum resources are widespread, both on and offshore.

Not only does Australia have a large range of significant resources, but the known resources for most commodities show an almost continuous yearly expansion over the last decade[5]. This reflects an active exploration and extraction industry which makes a substantial contribution (about 7 per cent) to the Gross Domestic Product (GDP), with mining directly employing around 260 000 people[6] or 3.25 per cent of employment. When sectors that directly support and are supported by mining are added, the total contribution rises to 18 per cent of GVA (gross value added) and 10 per cent of employment[7]. Australia's mineral exports were worth approximately $107 billion from July 2012 - June 2013, representing approximately 61% of total exports (goods and services)[8].

1 http://www.ga.gov.au/

2 Fraser Institute international Survey of Mining Companies 2012/2013.

3 The Territorial Sea is a belt of water not exceeding 12 nautical miles in wdith measured from the low water mark. (Source: www.ga.gov.au/marine/jurisdiction)

4 Figures compiled by Geoscience Australia from listed companies' ASX announcements of Mineral Resources reported in compliance with the JORC Code. http://www.ga.gov.au/minerals/basics.html

5 McKay, A.D., Meizitis, Y., Porritt, K., Champion, D.C., Britt, A., Whitaker, A., Summerfield, D., Sexton, M., Jaireth, S., Huston, D., Hoatson, D., Schofield, A., Carson, L., Towner, R., Huelatt, M., 2013. Australia's Identified Mineral Resources 2012. Geoscience Australia.

6 Australian Bureau of Statistics 2011.

7 Rayner and Bishop, Reserve Bank of Australia February 2013.

8 Bureau of Resources and Energy Economics (BREE) Resources and Energy Quarterly Report December 2013.

A number of interdependent factors have enabled the development of Australia's exploration and mining industries including:

- A rich and diverse natural endowment coupled with a global demand for a wide range of mineral and energy resources,
- A number of large discoveries of global significance that cemented perceptions of Australia's prospectivity[9],
- Steadily improving infrastructure (e.g. roads, rail, electricity, ports),
- Development of innovative mining and processing technologies, a skilled work force, and a strong mining equipment, technology and services (METS) sector,
- Strong policy, fiscal and legislative frameworks that provide transparent and integrated regulatory regimes,
- Stable government and security of tenure, and
- Provision of high quality public or 'pre-competitive' regional-scale geoscience information.

Characteristics of the mining/extraction industry

Exploration and development of mineral and energy resources differ from most other economic activities in a number of important ways:

1. **The location is constrained by geology**

   Mineral and energy resources are commonly located in remote areas, and sustaining production activities requires new resources to be identified as existing resources are depleted. Discovering new resources can be hampered by limited knowledge of the geology. Further, there is commonly a great deal of uncertainty associated with critical considerations such as the type, number, grade, tonnage, metallurgical character and location of deposits. Geology and location also affect costs (e.g. labour, materials, energy and capital)[10].

2. **There are long lead times between exploration and production**

   In a best-case scenario, the lead time from the start of the initial survey work to the launch of a new mine is between five and ten years, but can be up to two decades[11]. This means that today's investment decisions must accurately predict consumer demand years into the future, as well as consider factors such as variability in interest and exchange rates, and general economic conditions.

3. **The industry is mobile**

   Even though Australia has large economic resources of many mineral commodities, this is not a guarantee that such resources will be converted to extractable reserves. In a globalised and competitive commodity market, multinational mining companies are influenced in their investment decisions by perceived risks and likely returns on exploration investment. Considerations include the quality of resources (grade, tonnage and metallurgical properties) as well as environmental, social and political factors, land access, and the location and scale of competing projects worldwide.

Exploration and mining is a high risk business

Exploration and the resource discovery stage is a significant first step towards achieving a wealth generating asset. This is because exploration does not inevitably lead to mining or extraction activities and in fact this is rarely the case for most mineral resources.

... it takes 500-1000 grassroots exploration projects to identify 100 targets for advanced exploration, which in turn lead to 10 development projects, 1 of which becomes a profitable mine (Eggert, 2010).

For bulk commodities and petroleum, the discovery rate is generally higher than for precious and base metals, but exploration is still a high risk activity for which many other factors (e.g. infrastructure) are extremely important (Cairns et al, 2010).

Because of the risks and the range of factors involved in successful exploration from concept generation to technological advances, ground is typically held and explored by numerous companies before a mineable orebody is defined.

An example:*.....the discovery of the Century Zinc deposit in northwest Queensland came more than 100 years after lead-zinc was first found in the area (Main, 1993).*

[9] Examples include the 1883 discovery of Broken Hill lead/zinc, which changed the emphasis from gold to base metals and other ores; Mount Isa, established in 1928, one of the most productive single mines in world history (based on combined production of lead, silver, copper and zinc) raising Qld's profile for base metal exploration; iron ore of the Hamersley Basin discovered in the 1960s, one of the most massive ore bodies in the world with economic demonstrated resources today of 24 gigatonnes; the 1892 discovery of gold in the Eastern Goldfields (WA) which now includes the Super Pit, established WA's credentials as a world-class resource region; the expansion of coal mining in the Hunter Valley and Bowen Basin establishing New South Wales and Queensland as world class coal regions containing some of the world's largest deposits of bituminous coal.

[10] There are also external costs associated with production (primarily environmental and community impact liabilities).

[11] Topp, V., Soames, L., Parham, D. and Bloch, H. 2008, Productivity in the Mining Industry: Measurement and Interpretation, Productivity Commission Staff Working Paper, December 2008.

Pre-competitive geoscience in Australia

Australian GSO's work programs produce a range of geoscience data and information and have been doing so since the 1880s. Regional geological research programs either acquire new information, or upgrade historical data sets and fill data gaps, through the acquisition of modern geological data. They generally do not focus on individual exploration tenements, but seek to encourage exploration efforts in both 'greenfield' and 'brownfield'[12] regions.

Originally, pre-competitive geoscience data and information was in the form of written reports and maps based on field observations, and were stored and managed through libraries. By the 1950s, technological developments introduced the concept of remote mapping and the wide use of aerial photographs and, increasingly, geophysics. Rapid developments in computing power and storage in the 1980s marked another major change in how information was analysed, compiled and displayed. Geochemistry, satellite imagery and the geophysical sciences all benefited from more sophisticated analyses and modelling technologies.

During the 1990s, access to the Global Positioning System (GPS)[13] for both navigation and positioning revolutionised exploration. Large databases containing GPS-supplied coordinates associated with descriptive information on rocks, structures and mineral deposit occurrences were quickly established. High-resolution airborne geophysics, a powerful tool for interpreting regional geology, was now affordable and could be used routinely as part of geological mapping. Geographic Information Systems (GIS) software enabled the superimposing of field sites on the geophysical images, resulting in considerable improvements in accuracy and speed of geological map making.

GIS software is now fully integrated into GSO operations and, increasingly, three-dimensional models are being used to assist geological interpretations. Basic datasets are integrated and modelled using a range of software and computational systems to provide new information on the geological history of regions and their prospectivity for undiscovered mineral deposits[14]. These data are commonly released as value-added information packages that contain reports and digital data in GIS and other formats[15]. Digital mapping is available at 1:100 000 and 1:250 000 scale and for some areas, at 1:500 000 or 1:1 000 000 scale.

Pre-competitive data routinely available include: regional surveys such as airborne geophysical surveys (principally magnetics, radiometrics, digital elevation data, some airborne electromagnetics and airborne gravity gradiometry), ground gravity, geochemical surveys, geological mapping, mineral occurrence mapping (geological and statistical information on operating and abandoned mines, active and dormant mineral prospects, and mineral occurrences), core photography and hyperspectral core scanning[16], geochronology, and rock property data (magnetic susceptibility and density).

GSOs also receive data through collaborative studies with universities and national research institutions, as well as international organisations. In addition, the states and territories impose reporting requirements on industry through mineral, petroleum and geothermal exploration and production licenses. Reports on exploration activity form a vital part of the exploration database maintained and made public by GSOs ('open file' company reports and associated data). Reporting on production licenses is focussed on production data for royalty collection and for formulating resource policy.

Physical collections remain an important part of Australian GSO archives. These data comprise items such as: paper reports, maps, plans and sections; drill core[17] and chip samples; mineral, rock and palynology samples; rock slabs and thin sections. The collections are catalogued and archived in core libraries, which are purpose-built storage facilities that allow examination and sampling of core by industry and researchers alike.

Australia's pre-competitive geoscience archives are extensive, and collectively comprise a high value national asset.

It is worth noting, however, that there is still a large amount of data that is generated but not added to government archives. Extending the public collection of data to exploration companies which do not currently report publicly on their mineral and energy reserves would address current gaps in the resource reserve information base and hence improve the attractiveness of Australia as an exploration destination. Mining Lease data is another example of valuable information that could be collected by GSOs and added to the archives.

[12] Greenfields and Brownfields refer to the extent to which previous exploration has been conducted. The general meaning of brownfields exploration is that which is conducted within close proximity to known ore deposits. Greenfields are the remainder. Greenfields exploration is highly conceptual, relying on the predictive power of ore genesis models to search for mineralisation in unexplored virgin ground. This may be territory which has been drilled for other commodities, but with a new exploration concept is considered prospective for commodities not sought there before. Greenfields exploration has a lower success rate, because the geology is poorly understood at the conception of an exploration program. However the rewards are greater because it is easier to find the biggest deposit in an area, and it is only with more effort that the smaller satellite deposits are found. Brownfields exploration is less risky, as the geology is better understood and exploration methodology is well known, but since most large deposits are already found, the rewards are incrementally less. Different strategies are employed by Australian GSOs to facilitate greenfield and brownfield exploration.

[13] GPS is a space-based satellite navigation system that provides location and time information. The GPS project was created and realized by the U.S. Department of Defense. Advances in technology and new demands on the existing system have now led to efforts to modernize the GPS system and implement the next generation of GPS III satellites and Next Generation Operational Control System (OCX).

[14] http://www.resources.nsw.gov.au/geological/about/the-history-of-the-geological-survey-of-new-south-wales.

[15] For example New South Wales Exploration Data Package, Version 2, 2008. http://www.resourcesandenergy.nsw.gov.au/geoproducts/details?editionid=432&productid=377

[16] Automated core scanning equipment that provides high resolution thermal and short wave infra-red measurements together with continuous high resolution imagery of the core has enabled GSOs to archive 'virtual' core.

[17] Selected drill core is acquired from companies under legislation and through co-funded government-industry collaborative programs. As a condition of clients sampling core held by GSOs, the resulting analysis reports and data must be provided for inclusion in the geoscience data archive.

Geoscience and the role of government

In Australia, there have been numerous independent reviews of public funding of pre-competitive geoscience information[18]. These reviews recognise the benefits of public geoscience information, including:

- **Encouraging exploration in high risk, potentially high return frontier regions[19],**
- **Applying the geological knowledge of known deposits to increase the chances of finding more deposits,**
- **Reducing risk and uncertainty right across the resources exploration industry, by enabling the use and re-use of geoscience data held in public archives,**
- **Encouraging the participation of a larger number of small private investors than would otherwise be the case,**
- **Preventing exploration activity falling to ineffectively low levels,**
- **Reducing expensive re-acquisition of data, thus focussing expenditure on acquiring new data,**
- **Maintaining Australia's competitive edge in attracting international exploration and resource investment,**
- **Increasing competition through processes for granting or renewal of licenses, tenements and concessions that are informed by the available geo-scientific data, and**
- **Harmonising the data at provincial and continental scales to underpin policy-making and regional development decisions[20].**

Similarly, in other developed and mineral-rich countries, the provision of geoscience data is justified in terms of "attracting exploration investment" and allowing industry to identify areas of favourable mineral potential. Existing geoscience data increases exploration efficiency by allowing companies to identify ground that is not prospective, where exploration expenditure is unwarranted. The data increases exploration effectiveness by providing key inputs to risk-based decision-making, effectively reducing geological uncertainty and enhancing the opportunities for resource discovery, all of which is aimed at attracting exploration investment for a sustainable resources sector. By reducing exploration costs and risks, public geoscience data not only improve returns on private investment, but also increase royalties and taxes to governments[21].

There is evidence that increased exploration activity, and discovery of economic resources, can be directly attributed to the release of pre-competitive data. The South Australian government estimates that its investments in pre-competitive data directly stimulate private exploration by a factor of 3 to 5 times the cost of providing basic data. The Queensland government estimates that for every $1 spent on pre-competitive data and data management, explorers spent $15 on their work programs. Geoscience Australia (GA) cites studies that showed each pre-competitive dollar generated, on average, $5 of private exploration expenditure. The impact on exploration effectiveness is apparent in anecdotal evidence of government geoscience data contributing directly to numerous commercial mining deposits, including the world's fourth largest copper and gold deposit, and the largest known uranium deposit, Olympic Dam.

Pre-competitive geoscience data integral to the discovery of Olympic Dam

The central southern part of South Australia was one of a number of areas considered favourable for economic deposits of copper mineralization by WMC geologists in 1974. This area was far too large to be explored in detail. ***The process of ground elimination and target selections required the use of all the available geological and geophysical information.***

Source: Rutter and Esdale, 1985.

Knowledge of the whole lithosphere is fundamental to an understanding of continental assembly and evolution. From a mineral exploration perspective, evidence suggests that some fundamental translithospheric structures or lineaments may be important to continental metallogeny and its spatial variation. ***Beginning with the seminal work of O'Driscoll 1975, working from coarse contoured geophysical data and aerial photos, lineament analysis was integral to the targeting and discovery of Olympic Dam.***

Source: Searching The Deep Earth 'A vision for exploration success': prepared by the UNCOVER group under the aegis of the Australian Academy of Science, 2012.

[18] Commonwealth, state and territory governments in Australia recognise both market failures and the public good that can be generated through the provision of 'pre-competitive' geoscience - Commonwealth of Australia, Policy Transition Group, 2010, Report to the Australian Government - Minerals and Petroleum Exploration, Canberra; ABARE, 2007, Mineral exploration in APEC economies, a framework for investment, ABARE Report 07.22; Commonwealth of Australia, Department of Finance and Deregulation, 2011, Strategic Review of Geoscience Australia.

[19] Overcoming market failure due to the disconnect between the very short term focus of the risk capital market compared to the longer-term gestation period required for well-conceived exploration programs. This is particularly the case in frontier regions where new discoveries are in the best long-term interests of all stakeholder groups: shareholders in junior companies; shareholders in major companies; the Australian nation; and global customers for Australian resources.

[20] The effective execution of development plans requires government coordination of state and market activities, which in turn requires basic information on where such activities are likely to occur and what government services and infrastructure services will likely be required. For resource-rich countries, planning requires knowledge of the countries existing stock of resources and where investments would most likely be made if prices or other factors such as resource policy changed.

[21] Duke, J.M., 2010. Government geoscience to support mineral exploration: public policy rationale and impact. Report for Prospectors and Developers Association of Canada.

Other examples include: porphyry copper-gold at Cadia, manganese at Groote Eylandt, bauxite at Gove, uranium at Rum Jungle, nickel at Greenvale and petroleum at Moonie.

The flow-on benefits of these investments into communities are recognised and welcomed by governments[22]. There is also strong recognition by industry of the value of GSO geoscience data holdings and of their impact on initial investment decisions.

Research commissioned by the Australian National Data Service (ANDS) into the costs and benefits of providing free and open data confirms that the benefits outweigh the costs. The benefits are compounded over time as the data are used and re-used[23].

Newmont Australia (the Australian subsidiary of the world's largest gold miner) uses pre-competitive geoscience data in Australia to support its budget bids, when competing against other projects from around the world, at the company budget bidding process before management in Denver (USA).

We need the data sets to get over that first hurdle (preconceptions) and say, "Here's the geology, here are all the major elements... and this property is worth spending dollars on." This is particularly relevant in greenfields exploration....

Source: http://www.aph.gov.au/Parliamentary_Business/Committees/House_of_Representatives_Committees?url=isr/resexp/contents.htm

In Australia, the governments' objectives, as sovereign owners of resources and recipients of tax revenues from resource development, are to maximise their interests by attracting the largest competitive field of potential investors.

In this context, public geoscience information is seen as analogous to a prospectus intending to maximise the selling price of community-owned assets (in this case Australia's mineral and energy resources)[24].

To this end, every state and territory in Australia, with the exception of the Australian Capital Territory (which is very small and has no mining), has a GSO carrying out on-shore geological investigations within their jurisdictions, data archiving, and data management and dissemination. Geoscience Australia (GA), the national geoscience institution, works collaboratively with its state and territory counterparts under a 'National Geoscience Agreement' in the gathering and assessing of on-shore data (national and regional scale). GA has primary responsibility for off-shore pre-competitive information, and stores data, information and samples generated by exploration companies exploring off-shore basins. GSOs provide data, information and services to a wide range of government agencies, industry and international partners[25].

A central theme for all Australian GSOs in providing 'pre-competitive' data is to:

... establish competitive advantage in attracting exploration and development investment, and to market globally the attractiveness of Australia for mineral and energy exploration.

[22] http://www.aph.gov.au/Parliamentary_Business/Committees/House_of_Representatives_Committees?url=isr/resexp/contents.htm

[23] Houghton, J., 2011. Costs and Benefits of Data Provision. Report to the Australian National Data Service by the Centre for Strategic Economic Studies, Victoria University. http://ands.org.au/resource/houghton-cost-benefit-study.pdf

[24] Commonwealth of Australia, Department of Finance and Deregulation, Strategic Review of Geoscience Australia, 2011.

[25] A national research organisation, CSIRO is also an active participant in exploration research, including information management, and is a major participant in collaborative projects such as AuScope. AuScope Limited is a non-profit company formed to facilitate the implementation of a world-class infrastructure system for earth science through the delivery of a range of technologies and capabilities in data acquisition, management, modelling and simulation across the geospatial and geoscience spectrum.

AUSTRALIAN GEOSCIENCE DATABASES

Strategic directions and national standards

Under the Declaration of Open Government, the Australian Government has committed to a culture of engagement, built on better public access to and use of government held information sustained by the innovative use of technology[26]. As such, public data is to be published in open and standards-based formats that are machine readable[27].

Australian GSOs are the stewards of vast amounts of digital data and information, from continental, regional and province scale raster and point datasets to individual company reports. The GSOs have had to develop governance frameworks and structured data management protocols to gain the full benefit from their archives and meet the overarching Government objectives.

CSIRO, the national research organisation, has also had significant input through Flagship initiatives and projects such as Spatial Information Services Stack (SISS). SISS provides architecture and tools for information systems, and is being deployed to a number of government agencies across Australia. It is an overlay to existing State/Territory systems and provides users with seamless access to data themes across the continent, sourced from participating jurisdictions.

Managing the geoscience databases also requires strategic thinking to anticipate the demands of the future. The users of today interact with the data archive in ways that will seem restricted in the future. There is a need to provide a richer environment for users accessing the database beyond the current web-based tools. Currently, data warehoused information can only be interrogated by a limited number of tools. Machine to machine linkages will overcome this restriction, customising data 'behind the scenes' as the user PC communicates with the archive directly. Users will then be able to more fully incorporate the data archives into their desktop work flows.

There are a number of national co-ordinating and liaison committees that provide essential overarching direction on data management and delivery:

1. **Australia New Zealand Land Information Council (ANZLIC)**

   ANZLIC is the peak intergovernmental organisation providing leadership in the collection, management and use of spatial information in Australia and New Zealand. ANZLIC is responsible for developing nationally agreed guidelines for spatial data management. Its vision is to link a distributed network of databases by common policies, standards and protocols to ensure compatibility. ANZLIC works within the Office of Spatial Policy (OSP), a Federal government body[28] which facilitates and coordinates spatial data management across Australian government agencies. All jurisdictions participate in ANZLIC and it is up to each jurisdiction to decide how they will comply with and implement ANZLIC outputs.

   Policies and guidelines that have been developed include:

   Spatial data access and pricing policy, which was instituted to improve accessibility to Australian Government spatial data[29]. Under the terms of this policy, spatial data are provided:

   - Free of charge over the internet,
   - At no more than the marginal cost of transfer for packaged products, or
   - At the full cost of transfer for customised services.

   There are no restrictions on commercial value-adding or on-selling and spatial data is provided subject to a licence setting out the conditions of use.

   Custodianship guidelines, which provide guidance to Australian Government agencies on rights and responsibilities related to the acquisition and management of spatial information. This includes determining how the information will be managed and assigning any access constraints, as well as setting out the responsibilities associated with maintenance, quality and enabling appropriate access.

   ANZLIC also sets standards recognising the need for industry and other users not only to be able to draw together datasets from several custodians, but also to be able to assemble from them new, value-added products with the minimum of effort. This requires widespread adoption of common data standards. An example is the ANZLIC Metadata Profile which was established to facilitate the consistent collection of metadata (or information about data) across Australia and New Zealand. This Profile is based on international standards (International Metadata Standard ISO 19115) and defines a minimum set of elements that must be collected for spatial datasets and other resources, while at the same time providing the flexibility for agencies to extend the Profile and capture more information about a dataset or resource in order to meet their own specific business requirements.

[26] This was supported by the amendment of the Freedom of Information Act 1982 in November 2010 to include a new objects clause, which declares that information held by the Government is to be managed for public purposes, and is a national resource.

[27] http://electionwatch.edu.au/sites/default/files/docs/labor%20nbn%20Advancing-Australia-as-a-Digital-Economy-Book-Web.pdf

[28] An organisation within the Commonwealth Department of Resources, Energy and Tourism (RET). OSP incorporates the former Office of Spatial Data Management which existed previously under Geoscience Australia.

[29] The case for charging users for pre-competitive geoscience data acquired by GA was recently analysed by the Commonwealth Department of Finance and Deregulation (DoFD - 2011). DoFD reinforced the position that it was in the government's and the community's interests to fund pre-competitive information in order to attract the largest possible competitive field of potential investors. The NSW Department of Trade and Investment, Regional Infrastructure and Services has established a new rental fee on the mining industry to fund the continuance of its pre-competitive geoscience program "New Frontiers". While all jurisdictions levy annual rental fees on exploration tenure, NSW is the only jurisdiction to directly link the revenue collected from those levies to pre-competitive funding.

2. **Exploration Investment and Geoscience Working Group (EIGWG)**

EIGWG makes recommendations regarding collaborative geoscience data acquisition programs, promotion and marketing plans, trialling of new exploration technologies, and standards for management and delivery of geoscience information.

The EIGWG comprises the Directors/Executive Directors of the state and territory GSOs and GA's Chiefs of Minerals and Natural Hazards and Energy Divisions and Chief Executive Officer. The Government Geoscience Information Committee (GGIC) is a subcommittee of EIGWG and comprises representatives from Australian and New Zealand GSOs. Committee members have varying backgrounds including information management, information technology, geology, geophysics and cartography.

The annual GGIC work program includes:

- The development and implementation of national geoscience-related information standards and data models,
- Data access and delivery solutions and monitoring new and emerging trends in this domain,
- Making recommendations to EIGWG to sponsor projects that will improve data and information exchange, and
- Managing the National Geoscience Portal as a single entry point to all Australian geoscience jurisdictions (http://geoscience.gov.au/)

GGIC makes recommendations such as setting the requirements for digital exploration data supplied by industry to GSOs, specifying that incoming data must:

- Contain comprehensive metadata (e.g. what type of data it is; where it was collected; when; how),
- Conform to commonly used file formats,
- Be supplied in non-proprietary ASCII format where possible (e.g. drilling and geochemistry tabular data), and
- Include exploration reports, which must also meet compliance standards.

A free tool – the MinEx Report Template (MRT) software – is available from Australian GSO websites to assist explorers to meet the requirements. Digital reports are required to include the report document as a pdf file, include geophysical and imagery files, provide ASCII tab delimited files of point data such as geochemistry and drilling, and provide an ASCII metadata header file. Reporting requirements (content and file formats) are defined for all mineral exploration, geothermal exploration, petroleum exploration, petroleum well, seismic survey or airborne geophysical survey, mineral development licence, petroleum lease, and petroleum pipeline licence reports and some other exploration related reporting. The standards ensure that subsequent explorers can use the reports to assess prospects for mineral or hydrocarbon discovery and can avoid unnecessary expenditure in repeating previous investigations.

The national geoscience authority (Geoscience Australia) plays a lead role in implementing Australian geoscience information policies, standards and data models.

Examples include the Creative Commons Licensin Framework and the GIS Geoscience Data Dictionary. **The Creative Commons Licensing framework** has been fully adopted by GA (and subsequently by other jurisdictions) to enhance public access by providing simple, royalty-free, modular, off-the-shelf licences to all its online products. This form of licensing means that the data can be used without prior approval from the government, provided that the copyright declarations and attributions remain as part of the data. **The GIS Geoscience Data Dictionary** provides the specification for the capture of geoscience GIS data and forms a foundation for the production of Australian GSO GIS data by specifying rules regarding data structure, and defining allowable coverage names, feature types and attribute values. GIS data symbology (Data Standards and Symbols) provide specialised line and marker symbols for use.

3. **Australian Governments Open Access and Licensing Framework (AusGOAL)**

AusGOAL "provides support and guidance to government and related sectors to facilitate open access to publicly funded information. AusGOAL makes it possible for organisations to manage their risks when publishing information and data in a way that drives innovation and entrepreneurial activities, providing enhanced economic and social benefits to the wider community. AusGOAL is aligned with numerous open government initiatives around the world and supports the Australian Information Commissioners Open Access Principles (HTML - HyperText Markup Language)[30]. "

Amongst the tools provided through AusGOAL are licensing suites including Creative Commons Version 3 and Restrictive Licence Templates. AusGOAL is intended to reform the management and reuse of Australia's publicly funded information, which comprises a large part of State/Territory geoscience databases. The other major component of the geoscience databases, which is the information supplied by exploration companies, is provided outside of these licensing frameworks.

[30] http://www.ausgoal.gov.au/overview

There is a broad range of data sources and the widespread use of geoscience information across a range of disciplines has created a need for standards. Standardisation is a global trend that ensures compatibility between different datasets and greatly assists searchability when the data need to be retrieved.

'Standard Geoscientific Data Models' are used to establish an agreed best practice in the way in which geoscience data are organised and presented. There are three broad types of standards:

Content standards – such as Sample Numbers (International Geo Sample Number Implementation Organisation – http://www.igsn.org),

Access standards – including initiatives towards developing an Open Web Platform which is proceeding under the auspices of the World Wide Web Consortium (http://www.w3.org/), and

Exchange standards – such as the International Geological Data Model GeoSciML, a data model for exchange of geological map data and an Extensible Markup Language (XML) that defines a set of rules for encoding documents in a format that is both human-readable and machine-readable. The objective is to emphasise simplicity, generality and usability over the Internet.

The recommended minimum standards for submitting data to Geoscience Data Archives in Australia are set by the national co-ordinating committee - The Government Geoscience Information Committee - which provides a detailed report and reviews the standards annually, ensuring alignment with national consensus and international standards where they already exist.

State and Territory practices and policies

The quality and consistency of data management practices can vary due to a variety of reasons including budgetary constraints, staff turnover, technology change-overs and updates. Consequently, there is variation in the approaches taken by different Australian jurisdictions. However, a number of general principles are recognised by all the Australian GSOs as being conducive to best practice for geoscience data management:

1. **Centralised data warehousing**

   Centralised data warehousing requires key geoscience data[31] to be in a single location on fully maintained servers with fully tested back-up systems. This approach provides a 'master archive' where 'source' data (primary and derived) are protected to avoid deletion, over-writing or corruption, as well as overcoming issues of multiple versions of data. Disaster recovery strategies typically involve off-site storage of back-up copies of data on Write-Once-Read-Many (WORM) cartridge media. The data cartridges are held in robotic libraries for fast access as required.

   When data are updated, users linked to the central source automatically receive these revisions, ensuring that only the latest information is available for use. Other advantages include lower administration, support and maintenance costs, easier development of common solutions, and the ability to develop and maintain quality assurance standards. An alternative to Centralised Data Warehousing is Distributed Databases, which allow flexibility in choosing vendors and support services[32].

2. **Standard agency GIS environment**

   Establishing a standard GIS environment within a GSO has a number of advantages including:

   - Potential savings on licensing costs,
   - Cost reductions associated with reducing the number of applications that need support, and
   - Fewer management issues (e.g. reducing the potential for multiple, unsynchronized data and "multiple truths", and reduced data conversion and associated errors).

   A potential disadvantage is 'corporate capture' where an organisation can become locked in to a system of high licensing and maintenance charges.

3. **Company reporting**

   Whilst reporting standards are set at a national level, the period for which reports and data remain confidential vary by jurisdiction. All jurisdictions have different rules on renewal of tenement grants, including the duration of a renewed exploration licence, the number of times a licence can be renewed and the 'relinquishment' requirements. Partial relinquishment entails the surrender of a certain percentage of the original tenement area and this in turn affects the period that exploration reports remain confidential.

[31] In some jurisdictions mineral, petroleum and geothermal are separate business groups and have their own data base systems.

[32] At a National level, the Spatial Information Services Stack (SISS) provides a seamless view of distributed databases located in different State/Territory surveys.

Generally, mineral exploration reports remain confidential during the currency of the exploration tenement for which they are submitted, with the exception of partial relinquishment reports which are immediately available to the public. For petroleum and geothermal exploration reports, confidentiality periods vary by type of report and data [e.g. well proposal report, well abandonment report, well completion (appraisal), well completion (development), seismic survey or other technical report] and are commonly set at 2 or 5 years. Links to the requirements for the different Australian jurisdictions are provided from the Geoscience Portal (http://www.geoscience.gov.au/exploration.html).

The Chief Government Geologists, through GGIC, have developed a national standard in regards to mineral and petroleum exploration reporting. Each jurisdiction has its own set of guidelines tailored to its legislation, but these are all based on the national guidelines.

Company reporting requirements – mineral exploration:

- Tenure information,
- Location map at 1:100 000 or larger scale, showing Map Grid of Australia (MGA) standard map sheet reference,
- Exploration rationale, the program undertaken and the exploration methods used, and
- Results of literature searches.

Body of report contains:

- ***Geological Data:*** regional setting and results of geological mapping must be described. Geological 'fact' and/or 'interpretative' maps are required and the datum must be specified. All maps must have a legend. Appendices include information such as petrological descriptions. Sample locations need to be shown on appropriate plans (or listed in drilling logs) or indicated by local grid co-ordinates and MGA or latitudes and longitudes. The datum must be specified.
- ***Geophysical Data*** (airborne surveys, ground-based surveys, down-hole surveys) consists of: raw and processed located data (digital data); gridded data and images; and interpreted results.

  Reports include results and interpretations of all geophysical surveys and include data details such as: date of submission, an A4 or A3 plan showing the location of the survey; flight lines, traverse lines and stations presented on maps with MGA; (datum specified) and significant cultural features which may affect the results (e.g. power lines). Specifications of the survey are required (i.e. type and date of survey and survey parameters, and any data recorded on terrain conditions, nature of ground, quality of electrical contacts and extent of drifts). A data acquisition report is required detailing the operations carried out and any processing, text descriptions defining what constitutes an anomaly over background, and relating anomalies to geochemistry, geology and the results of drilling; plans or sections showing processed data and interpretation at the same scales as the geological and geochemical plans.

  For ground geophysical surveys, located (or reduced basic) data, with adequate ties to MGA coordinates are required to be tabulated in appendices. The datum must be specified.

  Gravity data must include the station number, MGA co-ordinates, Australian Height Datum (AHD) elevation, absolute observed gravity and terrain correction, and must specify the methods and parameters used to calculate the Bouguer anomalies.
- ***Specifications are similarly set for: Geochemical Data, Drilling Data, Remote Sensing Data.***
- ***Statements of any resources and reserves identified must be included*** and must be in accordance with the *Australian Code for Reporting Identified Mineral Resources and Reserves* and the *Australasian Code for Reporting Identified Coal Resources and Ore Reserves* prepared by the Joint Committee of the Australasian Institute of Mining and Metallurgy, the Australian Institute of Geoscientists and the Australian Mining Industry Council.
- All reports should include a bibliography of other work, earlier reports cited, etc. and appendices (data) as appropriate.

(Source: http://www.geoscience.gov.au/exploration.html)

4. **Direct data transfer**

   The mechanism by which companies report their exploration activities varies by jurisdiction. In the last decade there has been a trend for GSOs to accept reports lodged digitally for work carried out on exploration permits, mineral development licenses and all petroleum tenure. The use of contemporary information technologies for 'online approvals' has increased the efficiency, effectiveness, openness, transparency and accountability of the approval/renewal process, creating benefits such as:

   - Reduced paper use,
   - Provision of real-time information,
   - Improved proponent and regulator relations/confidence,
   - Increased agency productivity,
   - Improved agency demand responses, and
   - Improved collaboration, integration and sharing of information between agencies.

Online approval systems

Electronic lodgement and online tracking are available in Western Australia and Queensland and allow applicants to log in to a website and monitor the progress of their application. This has the added benefit of establishing IT systems that can then be used for reporting.

The Western Australian and Queensland governments have committed to expanding these tracking systems, which will allow applicants to track the progress of their approvals, regardless of which government department is evaluating them.

Online lodgement provides more certainty and reduces approval timelines for proponents, and reduces administrative handling and costs for government. It is also seen as having the potential to provide information for use in addressing regulatory bottlenecks or inefficiencies.

http://mines.industry.qld.gov.au/assets/mines-pdf/streamlining_approvals_project.pdf

Due to technological constraints, there are practical limitations to online lodgement of data. Currently, Australian GSOs also accept lodgements via disk media, although 'cloud' repositories are being considered as a future option.

GSOs are also enabling their field staff to enter geological observations and measurements directly from field sites using field 'tablet' PCs and online databases. Data typically captured include:

- Locational data including GPS coordinates, the stratigraphic unit and outcrop description,
- Structural measurements from each site,
- Lithological descriptions and sample information, and
- Petrophysical measurements such as magnetic susceptibility, density and radiometric readings.

5. **Auditing and audit trails**

   Large investment decisions are based on government data so its integrity is critical. All inserts, deletions and modifications in databases are logged in sufficient detail to allow 'rollback' if required. This allows for the correction of errors in the database. External audits can be used to provide an independent assessment of the archive and examine the processes applied to new additions.

6. **Data assurance (integrity and security)**

   Data integrity tests are carried out for data completeness and correctness and, where appropriate, for compliance with national standards. These vary considerably between jurisdictions but ideally involve an initial manual check followed by automated validation; for example, that metadata meets GGIC standards, titles are consistent with recommended formats and there is compliance with lodgement standards (from GGIC recommended protocols). File sizes are routinely checked to see that they meet any limitations on the transfer capacity of networks. Technical reports ideally are scrutinised for technical content before or after being accepted and GIS datasets are checked before they are released to the public, usually using a sampling routine.

   Security is provided to the master archive by a 'firewall' that prevents unauthorised access from internet users. Inside the firewall, access is provided to a set of users with different authorisations, typically:

   - Manager – read only,
   - System administrator – create/update/delete,
   - Data custodian – create/update/delete,
   - Data packager – read only, and
   - User-internal – read only.

   Outside the firewall, public access is obtained by becoming a registered user, which allows access to services including delivery of data. Limited access is permitted for 'anonymous users' due to lack of identification of the inquirer for the delivery of products and services.

7. **Custodianship**

   For administrative purposes, the data archives are seen as containing a set of "information assets". Each information asset has a custodian. Data custodians are executive level officers who have responsibility for and knowledge of specific information assets, and set policy covering criteria such as quality, accessibility and security[33]. A custodian is accountable for the information assets in their care, but may use data managers to handle day-to-day custodial matters. Such staff ensure that the data under their management meet appropriate quality assurance standards set by the custodian. Information asset custodianship responsibilities are assigned to a role, rather than a person, so that they are maintained over time.

[33] http://www.qgcio.qld.gov.au/images/documents/QGEA_documents/SiteCollectionDocuments/Architecture%20and%20Standards/Information%20Standards/Toolbox/Information%20Asset%20Custodianship/Info%20Mangt%20R%20and%20Rs.pdf

8. Monitoring usage and feedback

All GSOs collect statistics that enable use of their systems to be monitored. Client feedback is obtained through networking at industry events, enquiries to industry peak bodies and direct contact with users. The monitoring and feedback are used to determine if the information is reaching the target client groups, and to provide guidance for future enhancements.

Technologies – system components and linkages

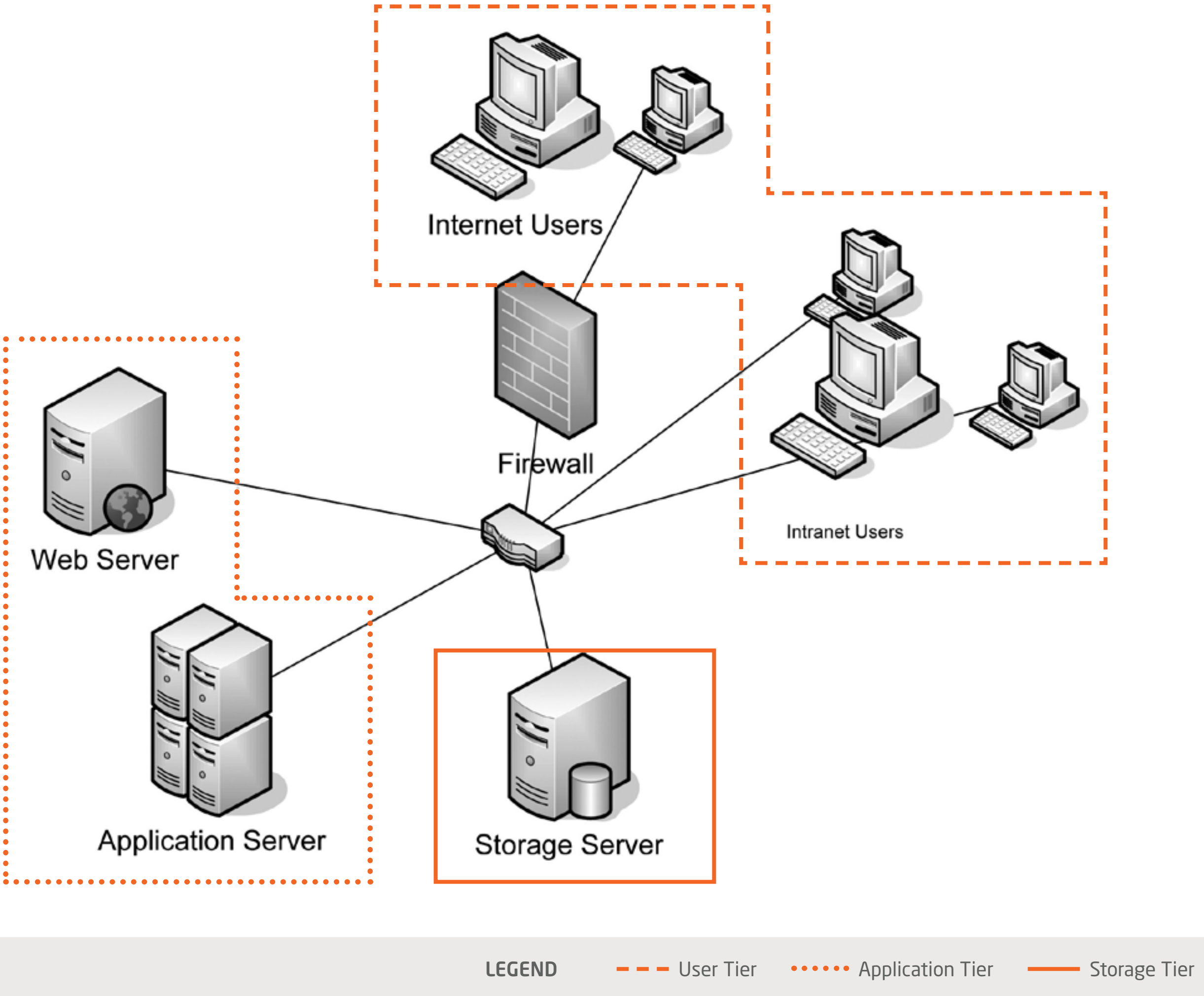
Digital geoscience data are commonly managed using three tiers of organisation (Figure 1), comprising:

- Storage – hardware servers where the data are stored,
- Applications – which provide facilities such as search and retrieve, and
- User modules – which provide the user with an interface to access appropriate tools to work with the data archive; different levels of access are provided to internal users, registered external users and anonymous external users.

"The essence of best practice in geoscience data management is data integrity, achieved through data validation, application of standards and inclusion of appropriate metadata. A good data governance framework that entails clearly defined roles and responsibilities, approval processes, documented policies, procedures and processes is also necessary. A national community of practice helps to gain cooperation from companies in meeting required reporting standards."

Northern Territory Geological Survey

Figure 1: Basic digital geoscience management system



Case study: Geoscience Australia's systems environment 2011

Storage infrastructure

Geological, geophysical, satellite remotely sensed, and topographic data and information involve very large data volumes. In particular, GA's geophysical data used as precompetitive information for the minerals and petroleum exploration industries, and satellite-related datasets totalled at least two petabytes.

Future storage is planned to include a full disaster recovery solution and is designed to scale up to at least 50 petabytes if required.

Application/software environment

The major applications systems used by GA are proprietary, commercial-off-the-shelf; for example, the ArcGIS product from ESRI. However, other applications are sourced from academia, open source communities or other collaborating groups. There are 60 discrete application areas such as 3D visualisation, data interpretation and geospatial modelling. In addition, GA has a large volume of software developed in-house (over 300 databases and 105 web applications).

As a consequence, a range of operating systems is required to support these applications – Linux, Unix and Microsoft operating systems – each requiring their own patching, upgrades and technical support.

Source: Commonwealth of Australia, Department of Finance and Deregulation, 2011

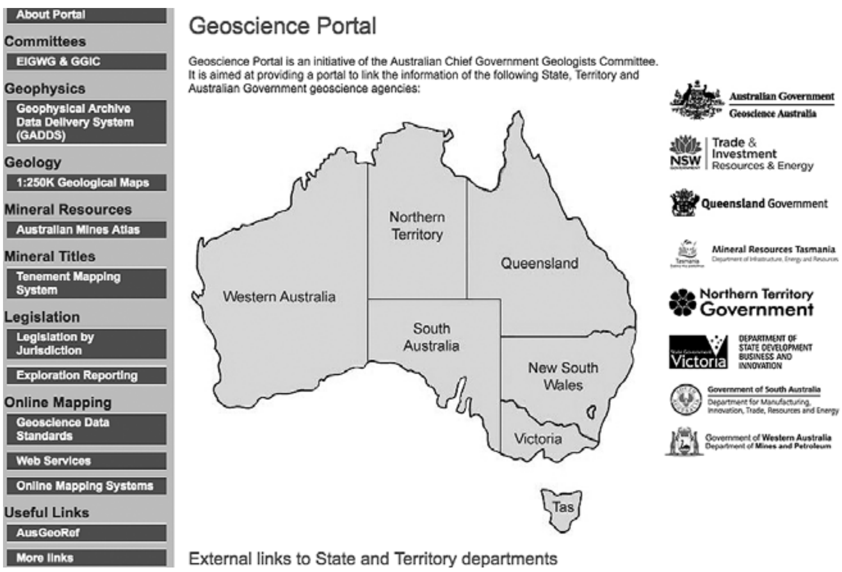
User modules for external users

To deliver this information to clients, GA has developed flexible and powerful online services via the internet for digital data delivery to ensure there is open and easy access.

The Australian Government's Geoscience Portal (Figure 2) gives users interested in exploring for minerals in Australia a single point of access to geological and geophysical data, and information about the legal requirements for exploration in all Australian jurisdictions (http://www.geoscience.gov.au/) . The portal provides:

- Links to all Commonwealth, State and Territory geological surveys,
- A download facility for all of Australia's geological map images at 1:250,000 scale,
- GSO acquired airborne geophysical data and digital elevation data downloads from all State and Territory Geological Surveys and Geoscience Australia,
- Links to all mining legislation and jurisdictional reporting guidelines,
- The national reporting guidelines for mineral exploration "Australian requirements for submission of digital exploration data" and the associated Mineral Reporting Template software,
- The Australian mines atlas, and
- A national view of current mineral tenements.

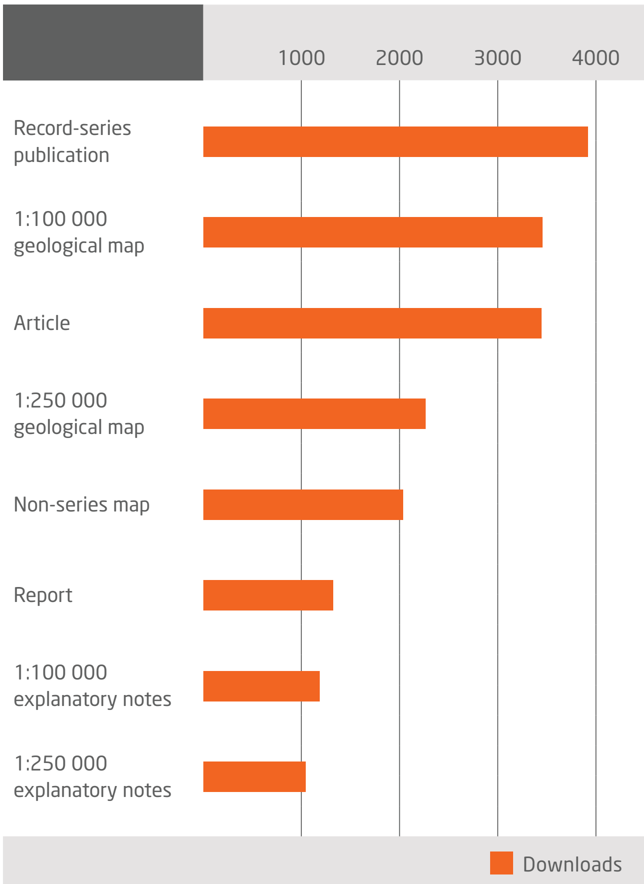
Figure 2: The Australian Government's Geoscience Portal



'Cloud computing'[34] is being assessed by GA as a means of overcoming increasing storage requirements. In this arena, internet companies are offering subscription services for online data management and storage offering data encryption and '24-7-365' availability. Open source options such as 'ownCloud' also provide storage, access, sharing, versioning, and search capabilities as well as access to a range of tools to work with the data[35]. Whilst the issues of long term reliability and security of data lodged in offshore computing infrastructure are yet to be resolved, GA has indicated a keen interest in cloud computing and sees great potential benefits from associated eResearch initiatives[36], in particular those focussed on data processing.

The National eResearch Collaboration Tools and Resources project, NeCTAR, is funded by the Australian government and has the objective of improving the way in which information and communications technologies help researchers to collect, manage, share, process, analyse, store, find, and re-use information[37]. Online processing tools are being developed through this initiative in a broad range of 'virtual laboratories' covering topics from astronomy to climate and weather. Amongst these is CSIRO's Virtual Geophysics Laboratory[38].

Figure 3: Data groups with more than 1000 downloads from the Geological Survey of Western Australia, July-December 2012



In addition to these national systems and initiatives, each state and territory GSO has its own website which allows data and information to be displayed, selected, previewed and downloaded. The objective is to provide ready access to high resolution suites of data describing the bedrock geology for all significant geological provinces. Most sites also provide facilities for tenement applications, submission of reports and other legislative requirements. These sites are the first port of call for industry and are being developed as 'one stop shops' by GSOs.

The state websites are very active in providing geoscience data to clients. In the last six months of 2012, the Geological Survey of Western Australia provided over 24,000 processed datasets as digital downloads (Bandy, pers com). Figure 3 shows data categories that achieved more than 1000 downloads from the website during that six month period. In the 2012-13 financial year, over 70 000 GIS datasets were downloaded from the Western Australian site.

Web-based delivery tools are used so that the data may be readily accessed by exploration companies and other users anywhere in the world, at any time. Typically these comprise:

Electronic document management system:

- Online lodgement and retrieval,
- Template for statutory reporting of company exploration activities and results,
- Template for mines and prospects,
- Search, select and download exploration reports, and
- Access to other collections such as maps and reports produced by GSOs.

Online GIS system:

- Viewer to assemble and visualise spatial data sets, (e.g. geology, geochemistry, geothermal), tenure (mining tenements and petroleum titles) plus other administrative layers, and
- Download service (zipped ESRI SHP files, PDFs).

Direct access to archives:

- Using Web Map, Content and Feature Services (WMS, WCS, and WFS), a client can use their own software tools to communicate directly with the data archive rather than using the browser interface. Greater demand for this "machine-to-machine" communication is expected in the future, as it allows import of data into Google Earth, as well as industry-standard software such as ArcGIS and MapInfo.

Static website content:

- Web pages of information about projects and services,
- Simple PDF and JPG document downloads, and
- Online product store (under development) with e-payment gateway.

[34] Cloud computing encompasses any subscription-based service that, in real time over the Internet, extends IT's existing capabilities. Eric Knorr and Galen Gruman, InfoWorld http://www.infoworld.com/d/cloud-computing/what-cloud-computing-really-means-031

[35] Document viewer http://owncloud.org/

[36] Feedback on 2011 Strategic Roadmap for Australian Research Infrastructure Discussion Paper: http://www.innovation.gov.au/Science/ResearchInfrastructure/Submissions/2011Roadmap_DP_Sub_GeoscienceAustralia.pdf

[37] eResearch Australasia 2013.

[38] http://www.nectar.org.au/virtual-geophysics-laboratory

Increasingly, jurisdictions are using technology developed specifically for high data availability and protection:

- Online GIS system with Google Globe and ESRI SHP format data, and
- Systems for delivering large spatial data sets online, including searchable catalogues of geophysical surveys[39] (EM, magnetic, radiometric, gravity, hyperspectral and magnetotelluric), geochemistry survey analyses results (surface and borehole), downhole geophysical logs and other types of large data, thus allowing search and retrieval of public data sets too large for storage and delivery through other systems.

GSOs that as yet do not have capability to deliver large spatial datasets via the web (e.g. geophysics including seismic and geochemistry) provide them in the following ways:

- Pre-packaged and sold on disk as a product, or
- Custom packaged and delivered via FTP, Dropbox or on disk media.

Looking forward, GSOs anticipate.....

"The future evolution of information systems will see improvements in query and analysis tools, greater control over query results and reporting, expanded download facilities, and better links to external data."

Geological Survey of Queensland

"Increasing service to clients who are using smart phones and tablets to connect to websites."

Geological Survey of Western Australia

The design of the portal plays a critical role in determining what will be accessed and what impact it has on the users. Improvements to websites are likely to include:

- Icon-driven navigation,
- Providing applications for standard portable devices / mobile computing,
- Enhancements for touch interfaces, and
- Simple, innovative site design.

Ease of access to high quality data through modern technologies has been a major part of Australia's strategy to fund pre-competitive geoscience. This policy has had an impact on agency costs:

- WA 2009 Exploration Incentive Scheme included $13.8 million for an online geological mapping system and $1.5 million for online application processes.
- NSW Exploration 2000 included $8.4 million for computer based data delivery, data maintenance and online systems.
- NT is currently improving its systems for online information provision as part of the CORE (Creating Opportunities for Resource Exploration) program, a new $3.95 million government initiative.

Database management systems aim to serve most of the needs of most of the users while maintaining compatibility with other systems and applications.

Data storage and delivery systems need to be designed with the future in mind: Who will be the main users? What are their needs likely to be? What are the implications for information management systems?

Some GSOs have identified 'increased use of geoscience data beyond the mineral resources area into wider issues of land management. We also anticipate that there will be greater access to other government information sources to assist our clients in using our website as a one-stop-shop for earth resource information'

South Australian Department for Manufacturing, Innovation, Trade, Resources and Energy.

[39] The Geophysical Archive Data Delivery System (GADDS) provides for the download of magnetic, radiometric, gravity and digital elevation data from Australian National, State and Territory Government geophysical data archives. http://www.geoscience.gov.au/bin/mapserv36?map=/public/http/www/geoportal/gadds/gadds.map&mode=browse

Conclusions:

A number of fundamental principles underpin Australia's approach to the management of public geoscience data:

- The primary purpose of public geoscience data is to attract the largest competitive field of exploration investors who will discover a new generation of large low-cost mineral deposits and deliver returns to the community as rents/ tax revenues and improved infrastructure. Increasingly, pre-competitive data is seen as vital for the government and community to make informed decisions on broader economic, social and environmental management issues underpinning policy making and regional development decisions.
- Sophisticated information management systems are required not only to deal with the vast volumes and diversity of geoscience data but to ensure data security and integrity. Large investment decisions are made using public geoscience, so data integrity is critical. Reports submitted on exploration activity form a vital part of the public geoscience databases. Clients need to be confident that the information submitted is secure.
- GSO data archives are of national significance and require robust disaster recovery strategies.
- Pricing policies should encourage the use of geoscience data by the widest possible field of clients. Consequently, data are provided free of charge over the internet, at no more than the marginal cost of transfer for packaged products, or at the full cost of transfer for customised services.
- Benefits outweigh the costs of instituting an Open Data policy to encourage the wide use and re-use of data archives. The benefits are compounded over time, and are extended by widening the client base through publicity and education.
- National leadership and coordination is essential to establish a 'community of practice' and requires aligning international, national and states/territory approaches to data management and distribution.
- Governance frameworks and data standards (e.g. database models and data definitions; specification for the capture of geoscience data) are required to enable the effective capture of a wide range of data in forms that can be integrated and confidently interrogated with minimum effort.
- Consistent guidelines on information standards and interoperability frameworks are seen as the means to optimise access, reduce costs, remove duplication, and improve data quality.
- Roles in data stewardship and custodianship are essential within GSOs to realise greater integrity and confidence in the administration and delivery of information. Custodians ensure information datasets and products are of a consistently high standard and 'fit for purpose' as well as oversight quality control and quality assurance procedures before dissemination of information.
- Web based "One-Stop-Shops" for accessing geoscience data and carrying out automated transactions, such as those associated with tenement administration, increase effectiveness, transparency and accountability of the approval/renewal process, facilitate integration and sharing of information between agencies, and promote national/state prospectivity worldwide.
- Websites need to be designed to ensure data can be readily identified. Being 'user friendly' is a major aspect of improving access.
- Data management needs to be considered as an evolving process to meet current and future client needs. New data acquisition, processing, modelling and display technologies (e.g. 3D and 4D geophysical models) are requiring greater processing speed and ever expanding data storage and management requirements. Cloud computing is one future option that could provide access to "virtual data rooms", "virtual core libraries", "virtual laboratories" and expert service providers.
- Governments need to maintain and increase their knowledge, capacity and capability in managing and delivering information. New technologies such as mobile devices (e.g. smart phones and tablets) are providing new opportunities to extend the reach of the archives. Machine to machine linkages will also provide a more sophisticated interaction with data archives, resulting in seamless integration of archival data into a client's workspace.

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BIBLIOGRAPHY

ABARE, 2003. Public Geological Surveys in Australia. Report 03.15, Canberra.

ABARE, 2007. Mineral exploration in APEC economies, a framework for investment, ABARE Report 07.22.

ABS, 2011. Mineral and Petroleum Exploration December Quarter 2010, ABS report 8412.0, Canberra.

ACIL Tasman 2010. Evaluation of the Economic Value of pre-competitive information. Report prepared for the Department of Resources, Energy and Tourism.

ACIL Tasman, 2011. Value of pre-competitive geoscience: Costs and benefits of pre-competitive geoscience data collection and distribution. Report prepared for the Department of Resources, Energy and Tourism, unpublished.

Bowler, J., (Chairman), 2002. Ministerial inquiry into greenfields exploration in Western Australia. Department of Minerals and Petroleum Resources, East Perth. http://www.dmp.wa.gov.au/documents/Bowler_Report.pdf

Cairns, C. Hronsky, J. & Schodde, R., 2010. Market Failure in the Australian Mineral Exploration Industry: The Case for Fiscal Incentives. Discussion paper prepared with the support of the Australian Institute of Geoscientists.

Committee for Mineral Reserves International Reporting Standards, 2006. International Reporting Template for the Public Reporting of Exploration Results, Mineral Resources and Mineral Reserves. International Council on Mining and Metals. http://www.crirsco.com/crirsco_template_v2.pdf

Commonwealth of Australia, Department of Finance and Deregulation, 2011. Strategic Review of Geoscience Australia.

Commonwealth of Australia, Policy Transition Group, 2010. Report to the Australian Government - Minerals and Petroleum Exploration, Canberra.

Commonwealth of Australia, Department of Finance and Deregulation, 2011. Strategic Review of Geoscience Australia.

Department of Natural Resources and Mines, 2013. Open data strategy. Land and Spatial Information, Department of Natural Resources and Mines, Queensland. http://www.dnrm.qld.gov.au/__data/assets/pdf_file/0017/47231/dnrm-open-data-strategy.pdf

Duke, J.M., 2010. Government geoscience to support mineral exploration: public policy rationale and impact. Report for Prospectors and Developers Association of Canada.

Economic Development and Infrastructure Committee, 2012. Inquiry into greenfields mineral exploration and project development in Victoria, final report (Mr Neal Burgess MP, Chairman), Parliament of Victoria, Melbourne.

Eggert, R.G., 2010. Mineral Exploration and Development: Risk and reward, Paper presented at the International Conference on Mining, Phnom Penh, Cambodia 26-27 May, 2010.

EIGWG (Exploration Investment and Geoscience Working Group), 2012. Levers to improve Australia's global position for attracting resource exploration investment. Report to the standing Council on Energy and Resources.

Government Geoscience Information Committee, 2010. Australian Requirements for the Submission of Digital Exploration Data. Commonwealth, State and Territory Governments of Australia.

Government of Victoria, 2011. Inquiry into the benefits and drivers of greenfields mineral exploration and project development in Victoria, government submission, Economic Development and Infrastructure Committee.

Houghton, J., 2011. Costs and Benefits of Data Provision. Report to the Australian National Data Service by the Centre for Strategic Economic Studies, Victoria University.

House of Representatives Standing Committee on Industry and Resources, 2003. Exploring Australia's Future – impediments to increasing investment in minerals and petroleum exploration in Australia. Canberra.

http://www.aph.gov.au/Parliamentary_Business/Committees/House_of_Representatives_Committees?url=isr/resexp/contents.htm

Main, J.V., 1993. Mineral exploration, science, serendipity, psychology. In, The AusIMM Centenary Conference - Mining: Our Heritage - Our Future.

McKay, A.D., Meizitis, Y., Porritt, K., Champion, D.C., Britt, A., Whitaker, A., Summerfield, D., Sexton, M., Jaireth, S., Huston, D., Hoatson, D., Schofield, A., Carson, L., Towner, R., & Huelatt, M., 2013. Australia's Identified Mineral Resources 2012. Geoscience Australia.

Rutter, H., & Esdale, D.J., 1985. The geophysics of the Olympic Dam discovery. Exploration Geophysics 16 (3), 273-276.

Scrimgeour, I., 2011. Bringing Forward Discovery: Growing the Territory's resource industry, Northern Territory Geological Survey, Northern Territory Government.

Topp, V., Soames, L., Parham, D., & Bloch H., 2008. Productivity in the Mining Industry: Measurement and Interpretation, Productivity Commission Staff Working Paper, December 2008.

Productivity Commission, 2009. Review of Regulatory Burden on the Upstream Petroleum (Oil and Gas) Sector.

UNCOVER group, 2012. Searching The Deep Earth 'A vision for exploration success'. Report prepared by Australian Academy of Science.

ONLINE SOURCES

ANZLIC – the spatial information council – "the peak intergovernmental organisation providing leadership in the collection, management and use of spatial information in Australia and New Zealand"
http://www.anzlic.org.au/

AusGOAL – Australian Governments Open Access and Licensing Framework.
http://www.ausgoal.gov.au/overview

Australian Bureau of Statistics - 5204.0 - Australian System of National Accounts, 2011-12
http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/5204.02011-12?OpenDocument

Bureau of Resources and Energy Economics (BREE) - an economic research unit within the Australian Government Department of Resources, Energy and Tourism.
http://www.bree.gov.au/

Code of Practice for resource exploration (Victoria)
http://www.dpi.vic.gov.au/earth-resources/about-earth-resources/legislation-and-regulation/codes-of-practice/code-of-practice-mineral-exploration

Creative Commons Licencing – "Creative Commons works to increase sharing, collaboration and innovation worldwide."
http://creativecommons.org.au/

eResearch Australasia Conference 2013 - "Delivering eResearch to the Masses"
http://conference.eresearch.edu.au/about/

Fraser Institute International Survey of Mining Companies 2012/2013
http://www.fraserinstitute.org/research-news/display.aspx?id=19401

Geographical Statistics
http://www.ga.gov.au/education/geoscience-basics/dimensions/area-of-australia-states-and-territories.html

Geological Survey of New South Wales
http://www.resources.nsw.gov.au/geological/about/the-history-of-the-geological-survey-of-new-south-wales

Geophysical Archive Data Delivery System (GADDS) – a service provided by GA for the download of geophysical data.
http://www.geoscience.gov.au/bin/mapserv36?map=/public/http/www/geoportal/gadds/gadds.map&mode=browse

Geoscience Australia – Australia's national geoscience institution.
http://www.ga.gov.au/;www.ga.gov.au/minerals/basics.html

Geoscience Portal – provides links to Committees, Geophysics, Geology, Mineral Resources, Mineral Titles, Legislation, Online Mapping State/Territory GSOs
http://www.geoscience.gov.au/

International Standards – Committee for Mineral Reserves International Reporting Standards - Standards for publishing exploration results, mineral resources, and mineral reserves.
http://www.crirsco.com/template.asp

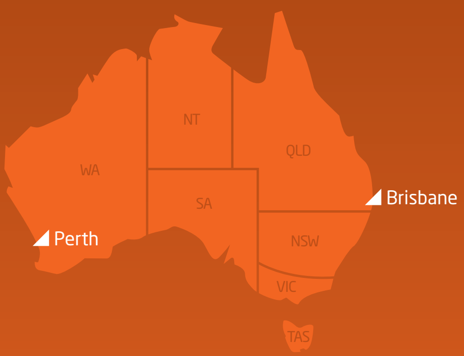
International Standards - International Geo Sample Number Implementation Organisation
http://www.igsn.org

Mineral Exploration Reporting Template – assists explorers to provide their exploration data in a standard format when submitting reports to Geoscience Data Archives in Australia
http://www.geoscience.gov.au/exploration.html

Open Geospatial Consortium - "Making location count." Aims to facilitate "... discovering and sharing geospatial data and processing resources across disciplines ..."
http://www.opengeospatial.org/

SCER (Standing Committee on Energy and Resources) 2012, Resource Reserve disclosure, http://www.scer.gov.au/workstreams/geoscience/resource-reserve-disclosure/

World Wide Web Consortium - an international community that develops open standards to ensure the long-term growth of the Web.
http://www.w3.org/



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