The Future Mine:
Trends and advances in technology

Peter A Lilly PhD
Director
Minerals Down Under National Research Flagship

Overview

• About CSIRO
• National Research Flagships
• Minerals-related research in CSIRO
• Some of the drivers of technology in the Australian context
• The Minerals Down Under Flagship
• A few examples of CSIRO technologies that will shape the future mine
• Conclusions
About CSIRO

• The Commonwealth Scientific and Industrial Research Organisation (CSIRO):
  • is a world-class research and development (R&D) organisation that plays a critical role in Australia’s innovation landscape;
  • employs more than 6,500 staff in 16 research divisions, and two joint ventures across 57 sites throughout Australia and overseas;
  • includes nine National Research Flagships addressing some of Australia’s most important and complex challenges;
  • is the largest single participant in the Australian Cooperative Research Centre (CRC) program;
  • hosts three National Research Facilities and manages 11 National Reference Collections;
  • has an annual budget of over A$1 billion (approximately $600 million comes from the Commonwealth Government); and
  • works across most sectors of science, engineering and industry.

• CSIRO’s core roles are as follows:
  • Addressing major national challenges and opportunities;
  • creating new industries (or significantly transforming them) to increase the competitiveness and sustainability of Australian industry;
  • delivering incremental innovation to improve the efficiency and competitiveness of existing industries;
  • providing fact-based solutions which meet community needs and knowledge that informs Government policy; and
  • advancing the frontiers of science, an essential component of maintaining long-term capability.

• More than 160 companies are founded on CSIRO technology and thousands of others utilise CSIRO innovations in their business.
National Research Flagships

- In Australia research funding is becoming ever more focussed on major National Priorities.
- National Research Flagships in CSIRO focus on major national challenges, and draw together capability across CSIRO, in universities and in industry.
- Nine such National Research Flagships have been developed to date:
  - Climate Adaptation (since May 2007)
  - Energy Transformed
  - Food Futures
  - Light Metals
  - Minerals Down Under (since May 2007)
  - Niche Manufacturing (since May 2007)
  - Preventative Health
  - Water for a Healthy Country
  - Wealth from Oceans

Minerals-related research in CSIRO

- Total investment in minerals-related R&D within CSIRO is over A$100 million in 2007/2008, involving 500 people at nine sites located in five States.
- CSIRO works with several CRCs and numerous universities, both nationally and internationally.
- Research and technical services work occurs across the whole minerals value chain, from geological modelling and exploration targeting to mining and processing to light metals production and manufacturing technologies.
Doing business with CSIRO

- Collaborative research (co-investment with one or more companies)
- Contract research (single and multi-party)
- Consulting and technical services
- Commercialisation (e.g. licensing, spin-off company establishment)

A driver of technology: world population growth

Source: U.S. Census Bureau - Population Division, International Programs Center, International Data Base
Another driver of technology: workforce safety

Chart 1  Lost time injuries 1995-96 to 2004-05

Source:  

Chart 2  International metals/energy mining industry fatality rates 2004-05

Another driver of technology: worker availability

Net entrants to the workforce

Source: Access Economics

Between 2005 and 2015 the workforce will need to increase by 50% (70,000 people) (MCA 2007-08 pre-budget submission, December 2006)
The future of minerals in Australia

- There will be a sustained demand for Australia's mineral products.
- People in the industry will have to do more and produce more than they do today.
- This means fewer people employed per unit of output; however, they will be more highly educated and skilled.
- Mining will be taking place in more difficult conditions (lower grade, higher stress, higher temperature, more gassy).
- However, health, safety and environmental outcomes must be better than they are today.
- None of this can be done without using technology developed through investment in R&D.

Minerals Down Under Flagship

- Discovering Australia's Mineral Resources
  - Terrane-scale applications
  - Mineral system lifecycles and targeting
  - 3D mapping technologies
- Transforming the Future Mine
  - Enhancing knowledge from drilling
  - Geologically controlled surface mining
  - Non-entry automated deep mining
  - Low footprint sedimentary mining
- Releasing new Ore Reserves
  - Processing low grade and complex ores
  - Bulk leaching technologies for challenging ores
  - Novel mineral extraction processes
- Reducing the Minerals Industry's Footprint
  - Zero waste and full value recovery
  - Minimising fresh water usage
  - Energy recovery, renewable carbon and eco-efficiency
  - Managing toxic elements
- Examples of CSIRO technology for MINING applications follow
Borehole Logging

Fast, efficient, quantitative elemental information

One of CSIRO’s solutions:
• The borehole logging tool:
  • The prompt gamma neutron activation analysis (PGNAA) logging system has been able to provide quantitative elemental information for a wide range of elements for different commodities.
  • A proposal has also been developed to combine this capability with other complementary technologies to develop a trace element tool that will achieve sufficient sensitivities for key elements needed by mining companies.

The Issue
• Effective borehole logging technologies will have application all commodity areas including coal, iron ore, copper and other base metals.
• The ability to receive same day analysis rather than waiting days or weeks for lab results will save the industry both time and money.
Rapid mineralogical characterisation

Mine-based spectral sensing technologies (for example, for vastly improved iron ore resource delineation and grade control)

The Issue

- Iron ore is one of Australia’s largest export earners (almost $19 billion in 2007/2008).
- The industry is facing a number of challenges including:
  - declining Reserves
  - declining ore grades
  - increasing overseas export competition
  - a shortage of skilled workers.

One of CSIRO’s solutions:

To improve iron ore characterisation using a number of new and improved techniques including mine face scanning, drill core logging and remote hyperspectral imaging.

These techniques:

- save money through improved exploration and orebody delineation
- add value to the dollar spent on drilling
- provide geologists with tools to provide accurate and objective results (manual logging can have up to an 80% error margin).
An innovative 3D imaging system for the mining and construction industries is providing improvements of up to 500% in structural measurement productivity.

**Sirovision®**

- **The Issue**
  - Sirovision® was developed to help prevent catastrophic collapses of walls in open cut mines.
  - It needed to be able to survey difficult or unsafe areas from a distance.

- **Features**
  - Sirovision® uses digital cameras to capture stereo images. It produces accurate high resolution 3D images that model surfaces and structure.
  - An underground version has also been developed and CSIRO is testing a version that will autonomously analyse mine walls and alert operators if needed.
  - Sirovision® has demonstrated improvements in structural measurement productivity of up to 500%.
  - The payback period averages 24 days of use in the field.
Cosflow

A sophisticated finite element code for underground coal mining applications

Cosflow applications

- Surface subsidence
- Mine stability
- Impact of mining on groundwater
- Water ingress into mines
- Methane drainage and emission
Cosflow in subsidence prediction

Cosflow in water in-flow modelling
Cosflow modelling gas concentration in different seams as mining progresses

Dragline Operator Assist (DSA)
Assisting dragline operators in delivering productivity and safety improvements
Dragline Operator Assist (DSA)

One of CSIRO’s solutions:
• The DSA Operator Interface provides a dragline operator with seamless transfer between assist and manual operating modes.
• Performance of the assist mode matches that of the best skilled operators and is consistent.
• Industry studies have consistently found up to a 20% variation in operator cycle time.
• When coupled with Digital Terrain Mapping (DTM), DSA gives the machine a spatial awareness and the ability to dig to pre-determined plans.

The Issue
• The efficient removal of overburden in open cut coal mines is key to maximum coal recovery.
• Draglines are a key excavator in terms of open cut coal recovery.
• It is difficult to control the accurate removal of overburden.

Longwall Top Coal Caving

Extracting coal from thick seams more efficiently
Longwall Top Coal Caving

The Issue
• Coal seams that are more than four metres thick make up a large proportion of Australia’s resources. They are estimated to contain 6.4 billion tonnes of coal reserves.
• While longwall mining is currently the most productive method of mining underground coal, extraction heights in Australia are currently limited to 4.8 metres.
• This means that in thicker seams, a large amount of coal is left behind and effectively sterilised.

The solution:
• During the last 20 years, the coal industry in China has successfully developed a longwall system for mining coal seams that are 4.5 to 12 metres thick.
• The system is called Longwall Top Coal Caving (LTCC).
• LTCC is capable of recovering more than 80 per cent of a thick seam.
• CSIRO is conducting a two-year study of the geotechnical, mine environment and operational issues involved with introducing LTCC into Australia.

Rapid Roadway Development
Increasing roadway development rates in Australia’s coal mines
Rapid Roadway Development

The Issue:
- Current slow roadway development rates cause delays in longwall operations.
- Bolting operations expose workers to hazardous conditions.

The Aim:
- An Autonomous Conveying and Bolting Machine (ACBM) capable of significantly increasing development rates while relocating operators to a safer working position.

One of CSIRO’s solutions:
- Automated roof bolting
- Operation from a safer position
- A one step bolting process with a Self Drilling Bolt
- A mining machine (ACBM) platform for roof and rib bolters, bolt storage and coal transfer
- Remote sensing of roof structure through drill monitoring

Commercial benefits:
- Increased rates of development
- Lower development costs
- Improved knowledge of roof structure improves response to adverse mining conditions
- Automation systems can contribute to increased machine availability

The RRD project has contributed directly to the development of:
- A Self Drilling Roof Bolt
- A state of the art Control System

Longwall Automation

An automated system that cuts longwall downtime by two hours per day, delivering productivity and safety improvements.
**Longwall Automation**

*The Issue*
- Longwall mining is used in >80% of underground coal mines.
- The longwall operation makes up around 30% of the cost of production.
- The longwall is a hazardous and dusty environment
- It is difficult to control the position of equipment accurately

*One of CSIRO’s solutions:*
- A new shearer position measurement system using a military-grade inertial navigation unit that shows where the face equipment is in 3D space.
- Automatic face alignment.
- Automatic horizon control.
- Broadband shearer communications that enable the new control systems to work.
- CSIRO’s system cuts downtime by two hours per day and provides for more consistent control of equipment operation.
- Commercialisation through face equipment OEMs is well advanced.

**Microseismics**

Helping to foresee hazards during mining
**Microseisms**

CSIRO has made real progress:

- Research has focussed on the development of a multi-channel and intelligent microseismic data acquisition system and wireless transmission of seismic data from sensors to the central mine office.
- Online data processing and result visualisation are also under development.
- Data from the first field trials is being processed.

**The Issue**

- The development of real-time microseismic monitoring will have substantial benefits.
- It will allow the location of rock fractures and the prediction of impending hazards such as roof falls, rock bursts, water ingress, working area stability, fault reactivation and gas and steam emission.

**Real-time Risk Management**

The Nexsys™ underground communication system
Real-time Risk Management

The Issue
- It is vital that mine operators are continuously aware of underground conditions and risk profiles, and that communication systems stay active during power outages, fan stoppages or gas accumulations.

However, there are often:
- many different communication systems in use at most sites
- large numbers of system-generated false alarms
- time delays in locating people
- cumbersome manual statutory reporting systems, and
- extreme workloads in emergency situations

One of CSIRO’s solutions:
- The Nexsys™ Real-time Risk Management System for underground mines comprises:
  - The Nexsys™ software package.
  - An electronic report-capturing system.
  - A suite of Ethernet-based, fibre optic and intrinsically safe (IECEX.ia) communications devices suitable for use in potentially explosive atmospheres.

- Nexsys™ can:
  - Source information directly from proprietary systems
  - Integrate and interpret the data, and in accordance with a pre-determined set of rules, initiate a response to breaches of these rules

Automation of blast hole charging

Helping to remove people from hazardous areas
Automation of blast hole charging

**The Issue**
- Underground mining involves four basic stages: drilling blast holes, pumping explosives into those holes (charging), blasting, and removing the broken rock (mucking).
- In the past, blast holes were filled manually. More recently they have been filled with the assistance of a vehicle fitted with a hydraulic arm called a Mobile Charging Unit (MCU).
- Both methods require people to operate the equipment.

**CSIRO’s solution:**
- The charging of blast holes is an inherently hazardous operation and there are clear efficiency and safety benefits if it can be achieved by autonomous equipment.
- CSIRO is working with Orica to develop an automated MCU.
- The system is being developed in two phases. In phase one, the unit will be controlled by an operator in the cab of the MCU.
- In phase two, the unit will utilise automated loading.

SmartCut®

The holy grail? Mechanised mining for hard rock environments
CSIRO’s solution:

• Two key barriers stood in the way of this technology. The first was overcome in the change to thermally stable diamond (TSDC) composite materials in the late 1980s.

• The second barrier was overcome with the discovery by CSIRO of a bonding technology to join TSDC to the steel body of standard rock cutting picks.

• The SmartCut® technology uses thermally stable diamond composite cutting tips to cut abrasive soft and hard rocks.

• Wear rate of the new cutting tips is about one thousandth of that experienced by conventional tungsten carbide picks.

The Issue

• Drill and blast has been the only efficient way of moving hard rock. However, it is essentially a stop and go rather than a continuous mining method.

• There are large efficiency gains to be made if soft rock cutting techniques can be imported into the hard rock arena.

SmartCut in 114MPa sandstone
Wear comparison

SmartCut in 260MPa basalt
Concluding comments

• The future of mining in Australia is dependent on our state of technical knowledge, and the resultant technology and innovation that flows from this knowledge.
• These technologies and innovations must make the industry safer, more productive and environmentally sustainable.
• Technology comes from an investment in research and development.

Minerals Down Under National Research Flagship

Dr Peter A Lilly
Director

Phone: +61 8 6436 8613
Mobile: + 61 408 924 912
Email: Peter.Lilly@csiro.au
Web: www.csiro.au

Thank you