REPORT ON INTERNATIONAL COMMITTEE ON COAL RESEARCH (ICCR) VISIT TO SOUTH AFRICA 14-23 April 1997

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INTRODUCTION

The importance of safety in the underground coal mining industry is paramount to the increases in productivity the industry must achieve in order to realise adequate returns on funds invested.
These efforts to improve safety have intensified following the Moura Inquiry findings.
A new initiative arose from Australia's participation in the International Committee on Coal Research (ICCR) and the desire of the South African delegates to cooperate more closely with Australian researchers particularly in the field of safety research and demonstration.
Agreement has been reached to actively exchange information and experience in the areas of Coal Pillar Design, Fires and Explosions and Mines Rescue and Escape.
This cooperation has taken the form of nominated experts in each area collating relevant work done in their country. The Australian delegation visited South Africa from 14 to 23 April 1997 to both describe our work and to see at first hand what the South Africans are doing. The visit to South Africa was funded by the Australian Coal Association Research Programme (ACARP). The South Africans reciprocated in kind from 16 to 25 June 1997. The visit in South Africa was organised by the Mining Technology division of the Council for Scientific and Industry Research (CSIR).

HIGHLIGHTS OF THE VISIT

The major highlights of the visit were as follows:

- A new technique of suspending stone dust barriers, which is simpler and reduces manual handling considerably, has been developed.
- The South Africans have experience in actual emergency conditions with many of the escape techniques which have been proposed post Moura with hard evidence on what works and what does not.
- Light and sound guided escape systems in low visibility have been found wanting but cable guides have been found to be effective.
- The South Africans have considerable experience with oxygen based self rescuers.
- Some brands of SCOSRs which are banned in South Africa because of poor performance are being sold in Australia.
- A matrix of coal pillar types versus common research needs has been developed.
- Lessons learned in yield pillars in platinum and deep gold mines, plus crush pillars in longwall mining will find application in Australia.
- A large field experience base relating to pillars exists in South Africa across both its coal and its metalliferous mining industry.
- A large data base contained in research and technical reports resides in the Chamber of Mines, CSIR and mining houses (groups) in South Africa.

THE AUSTRALIAN AND SOUTH AFRICAN TEAMS

The Australian Team was as follows:
Mr Ray Parkin, Manager Health Safety and Environment, Shell Coal Australia - Team Leader
Professor Jim Galvin, Head of the School of Mining Engineering, University of New South Wales - Coal Pillar Design
Mr Paul Mackenzie Wood, Manager, Technology and Technical Services NSW Mines Rescue - Escape and Rescue
Dr David Cliff, Manager Mining Research, SIMTARS - Fires and Explosions

The South African Team was as follows:
Mr Harry Rose, Manager Health and Safety Ingwe Coal – Team Leader
Dr Bernard Madden, Miningtek - Rock Mechanics - Coal Pillar Design
Mr Jan du Plessis, Miningtek - Fires and Explosions
Dr Johan Kielblock, Miningtek - Escape and Rescue

The Australian visit to South Africa took place from 14 to 23 April 1997. The South African visit to Australia took place from 13 to 25 June 1997.
The itinerary for the visit to South Africa is described in **Appendix 1.**

OVERVIEW PRESENTATIONS

Chamber of Mines - Monday 14 April 1996

Overview presentations were made by the following people:

- Dr J.M. Stewart, Chamber of Mines
- Mr R.P. Mohring, Ingwe Coal Corporation
- Dr H.R. Hume, Chamber of Mines
- Mr S.M. Smith, Miningtek
- Professor H.R. Phillips, University of the Witwatersand
- Mr R.J. Parkin, Shell Coal Australia
- Mr J.P. van Rensburg, formerly Miningtek
- Dr D. Cliff, SIMTARS
- Mr J. du Plessis, Miningtek
- Mr P. Mackenzie-Wood, Southern Mines Rescue Station
- Dr B. Madden, Miningtek
- Professor J. Galvin, University of New South Wales
- Mr T van Rensburg, ex CSIR Miningtek

Others in attendance:

- Mr G. Gurntica, Director of CSIR Miningtek
- Dr A. Parsons, Personal Assistant to Dr J. Stewart

A number of presentations were made setting the general background of the South African and Australian Mining Industries.
For the visit programme see Appendix 2

The South African Coal Mining Industry

The South African Coal Mining Industry produces approximately 206 million tonnes of coal per annum, 82 M.T. is used for inland power generation, 63 M.T. is used for inland industrial purposes, such as fuel production (Sasol) and 55 M.T. is exported. The coal which is exported is mainly steaming; only 2 million tonnes of coking coal is exported.

There are 60 operating mines in South Africa. Of the total coal produced 53% comes from underground mines, where Bord and Pillar Continuous Miner accounts for 70 million tonnes, Drill and Blast 24 million tonnes, short wall and longwall produce approximately 10 million and approximately 6 million tonnes from short wall and longwall development. The geology of South Africa coal deposits limits the application of longwall mining. The technology used in the underground mines varies enormously. Continuous Miners are used mainly, because the coal is very hard. The industry employs some 60,000 people with a productivity of approximately 3,400 tonnes/man year. The major players in the industry are Ingwe 41% and AMCOAL 24%.

Chamber of Mines of South Africa

The South African mining industry has since 1993, financed safety research through a statutory levy. The research programme is determined by the Safety in Mines Rescue Advising Committee (SIMRAC) which is also responsible for setting the levy.
Some 600,000 people are employed in the Mineral Industry.
The Structure of SIMRAC is at Figure 1.

SIMRAC Funding

- Funding supports only Health and Safety related research.
- Funding is generated by a levy on mines, quarries and sand and gravel operations.
- All operations, other than those falling in the generic category, are levied annually under a formula that takes into account the annual number of allocated injury days per operation using a 3 year moving average.
- Operations falling into the generic category are levied individually on a head count basis.

Those with the worst safety record pay the most:
Allocation of SIMRAC funds:
From 1993 to 1996 the funds amounted to 199 million Rand.
75% Gold and Platinum
14% Coal Mines
11% Generic and others

STRUCTURE OF SIMRAC

In Operation since 1993

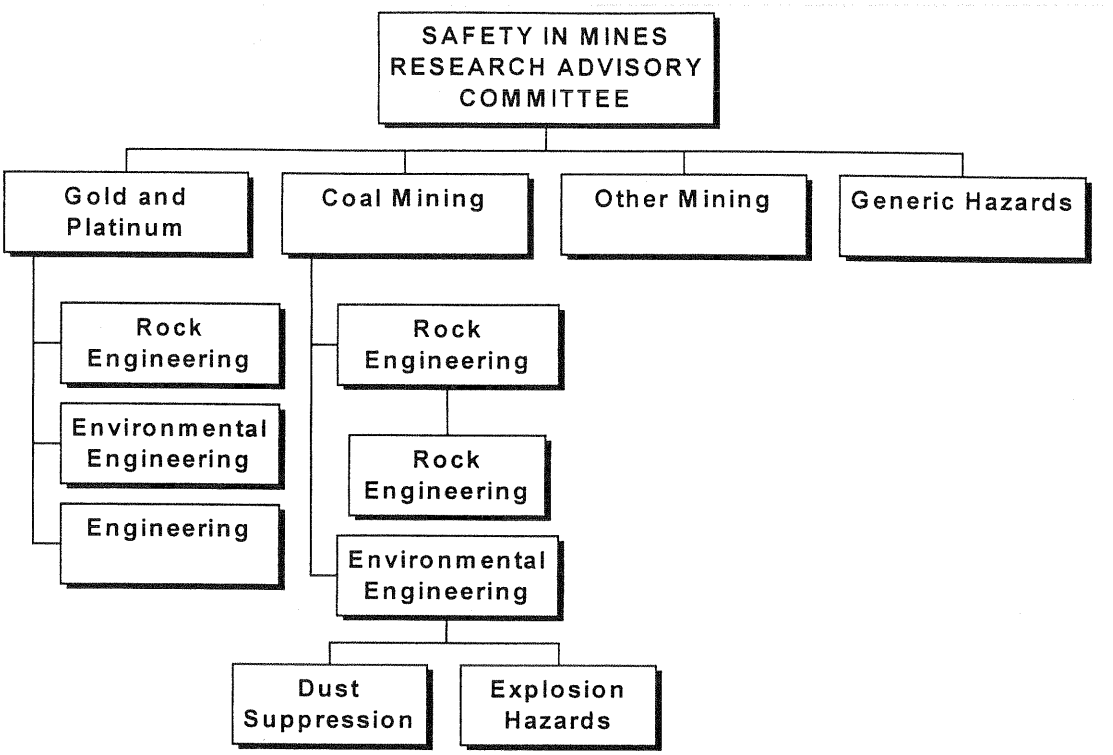


Figure 1

Safety considerations in the South African Mining Industry

The South African Mining Industry has a large multilingual and multi cultural workforce operating state of the art technology with a largely "third world" workforce of operators and labourers, the majority of whom are functionally illiterate.

In recent years the contribution of mining to the GDP has decreased from 15% in 1985 to its present level of 9%. South Africa still has a large well developed mining industry employing 600,000 people and accounts for 50% of the country's export earnings. However, the cost over the years, in terms of social disruption and mining accidents has been high.

When looking at the safety record of such a diverse mining industry the following considerations need to be taken into account - ultra deep, labour intensive gold mines where unprecedented conditions of heat and rock stress exist, to highly mechanised open-pit and shallow coal mines.

A survey of Odendaal Gold Mine 1995 indicated that workers returning from leave feel safer at work than they do at home, quoting road accidents and violence as their reason.

When data on road deaths from 20 countries is compared, South Africa with a rate of 32 fatalities/100,000 population is the highest, being double that of the United States of America and four times the rate in the United Kingdom.

Measuring the violence in South Africa, the murder rate is nearly 5 times that of the United States of America and over 40 times that of the United Kingdom.

Fatalities and Accidents in South African Mines 1988 to 1995

Currently 142 mines are operating

Total Fatalities 5,005

Total Injuries 75,001

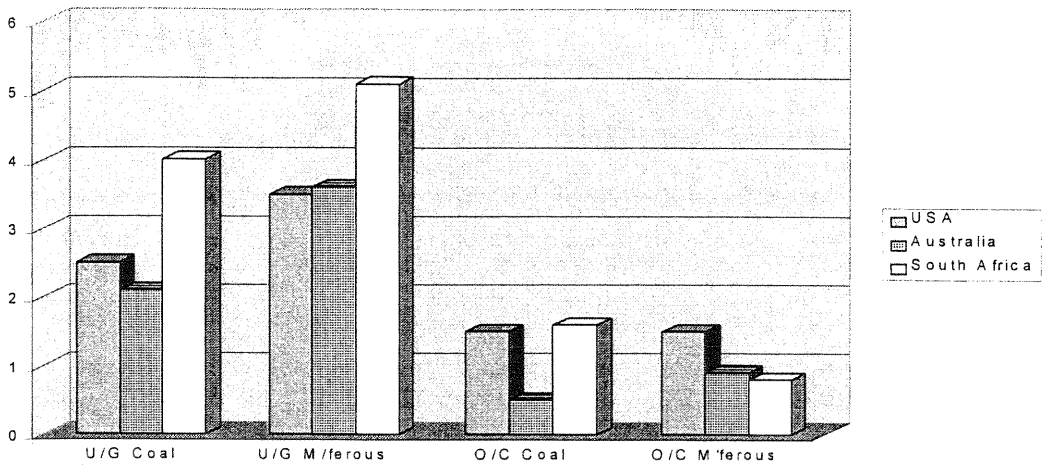
Approximately 625 fatalities and just under 10,000 serious injuries per annum. Gold mines account for 75% of fatalities and 10% are in coal mines. The majority of fatalities are from falls of ground, (approximately 58%).

In order to compare South Africa with Australia and the USA, the fatal injury frequency rate (FIFR) has been used, ie. the number of fatal injuries per one million man hours worked.

The South African Mining and extractive industries indicate a Fatal Injury Frequency Rate (FIFR) (1990-1994) of 0.43 compared to that of Australia (1987/88 - 95/96) of 0.13 and that of the USA (1991-1996) of 0.15.

Fatality data for the three countries is shown below:

International Mining Industry Fatality Rates



Australia average for 1987/1988 to 1995/96
Extractive industry average for 1993/4 to 1995/96
USA average for 1991 to 1996 calendar year
South Africa average for 1995 and 1996 calendar years only
Information sourced from the Minerals Council of Australia 1995/96.

- **Underground coal:** Australia and USA have similar FIFRs. South Africa's is much higher.
- **Underground metalliferous:** The Australian FIFR is similar to the USA's with South Africa much higher.
- **Open cut coal:** The Australian FIFR is lower than those of USA and South Africa.
- **Open cut metalliferous:** The Australian FIFR is lower than the USA and similar to South Africa.

When reporting international accident statistics, often the injury data is presented using different criteria, depending upon each country's legislative reporting requirements.
The injury rate for the South African Coal Mining Industry was quoted as being 4.26 per 1,000 at work. South Africa reports as injuries those which result in more than 14 days off work - it is therefore difficult to compare on an LTIF basis.
Average depth of gold mines is 2 kms. Western Deep Levels are planning to work at 5 kms deep. It was stated that in order to improve safety in South African mines improvements in the following area are required:

- Literacy programmes
- Communication
- Adult basic education
- Common language.

Miningtek (CSIR)

CSIR was established in 1945 and is statutory scientific research council employing 2,480 staff, with an annual budget of R266M - 59% external sources of income and 41% Government Grant.
Miningtek is one of nine divisions of CSIR and works with the Mining Industry, government institutions and employee organisations by acquiring, developing and transferring technologies to improve the safety and health of its employees, and to improve the profitability of the mining industry.

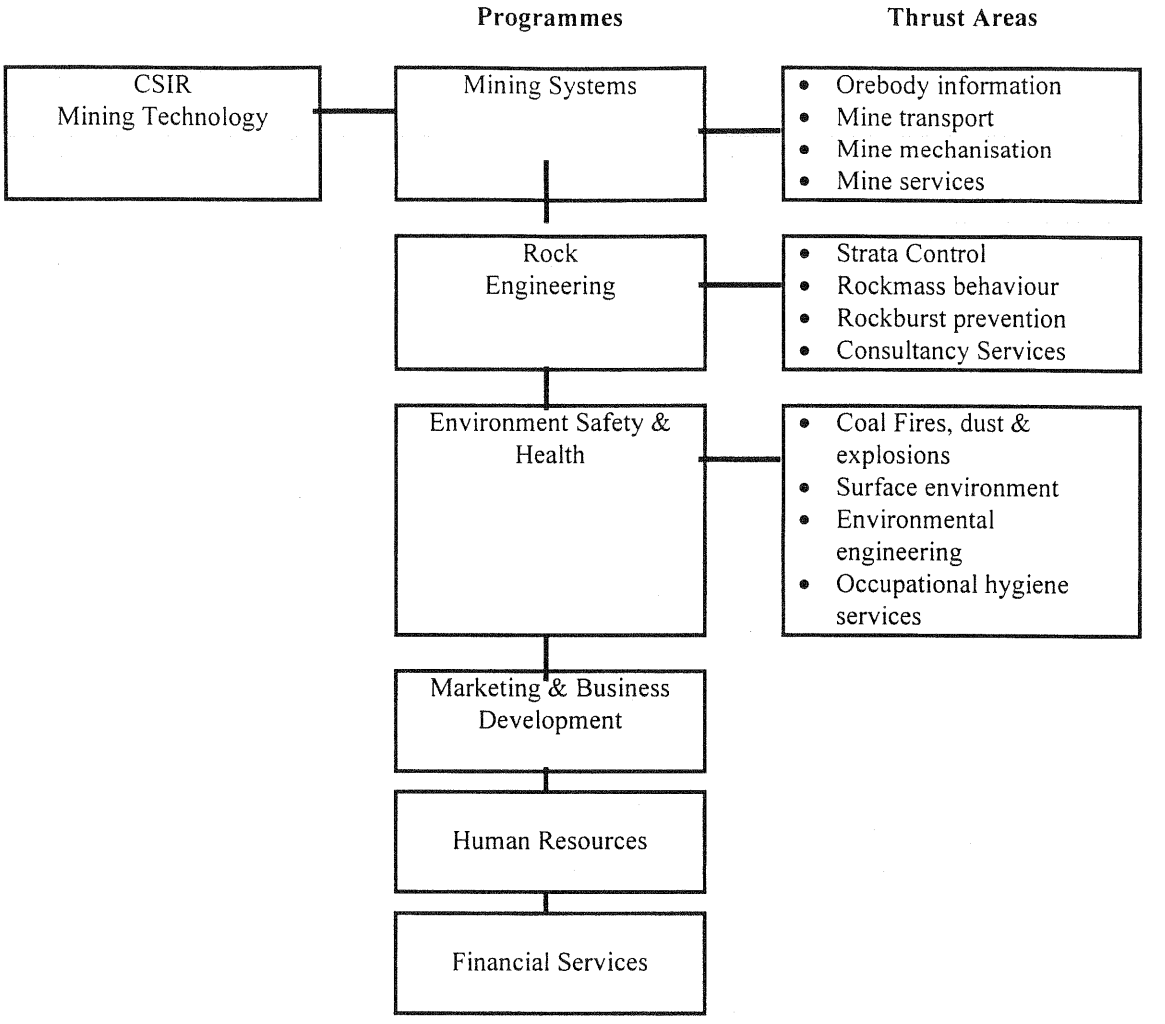
Miningtek employs 210 staff with an annual budget of R60 Million (A$19M).

SIMRAC levy	R25M
Parliamentary Grant	R13M
Chamber of Mines	R9M
Other	R13M

Miningtek in-house test facilities include:

- Support and rock testing
- Backfill laboratory
- Breathing Simulator
- Exercise laboratory
- Climate chamber
- Heat Exchanger test centre
- Analytical laboratories

Miningtek Structure



Major offsite test facilities include:

- Backfill test site - Western Deep Levels
- Kloppersbos Explosion Hazard Test Facility
- Experimental Flume - RAU (Rand Africaans University)

The Environmental Safety and Health branch of Miningtek employs 38 people and has a budgeted income of R14 million, 75% of which is external income.

The occupational hygiene research include heat stress management, physical work capacity and escape strategies. In recent times research has been focussed on the various issues regarding self contained self rescuers.

EXPECTATION OF AUSTRALIAN AND SOUTH AFRICAN ICCR MEMBERS

The expectations of the South African and Australian members were identified as follows:

- Three areas of collaboration which are self-energising.
- New approaches to the solution of persistent problems
- Cross fertilisation of ideas
- An exchange of data, research reports and publications in each of the three areas
- The establishment of personal contacts to serve as an active network for research in the various areas
- The establishment of pragmatic arrangements for exchanging and disseminating information.
- The establishment of procedures and measures to critically self-audit the collaboration on an annual basis.
- The following reports from each coordinator:
  - Noteworthy points from the interactions in SA
  - Noteworthy points from the interactions in Australia
  - A joint report from the two coordinators in each of the three areas setting out the collaboration arrangements, including research programmes and specific objectives that have been agreed to.

- A joint report from the two teams setting out comments on the experience and recommendations for improvement.

VISITS

- Chamber of Mines - Overview Presentations
- Kloppersbos Facility
- Miningtek Research Facility
- University of Pretoria/Witwatersrand
- Mines Rescue Services, Carltonville
- Mine Visits Coal
  - Kutala
  - New Denmark
  - Ermelo
  - Durban Navigational Division Collieries
- Mine Visits Gold & Platinum
  - Western Deep Levels
  - Amandelbult Platinum Mine

Mines Rescue Services, Charletonville, Tuesday 15 April 1997

Discussions were held with the following people:

- Mr. Roland Hooper, Managing Director, Mines Rescue Services
- Mr. Norman Graham, Assistant Manager
- Mr. H.R. Snelson, Superintendent, Carletonville
- Mr. G.G. Eave, Superintendent, Dundee
- Mr. B.J. Vorster, Superintendent, Evander
- Mr. G. Batterson, Superintendent, Welkom

Formation of Mines Rescue Services (Pty) Ltd

In line with the Chamber of Mines Policy of improvement, the Rescue Training Services was transformed into a stand alone company on 6 August 1966. The new company known as the Mines Rescue Services (Pty) Limited was incorporated as a wholly owned subsidiary of Chamber of Mines Services (Pty) Ltd. The appointed six member board of Directors consists of:

- one Chamber of Mines (Chairman)
- five Industry
- one Mines Rescue Services non voting

The board is responsible for strategic policy and major financial decisions, including budgeting approval following recommendations by the Committee of Management. The Committee of Management consists of ten people:

- one Mines Rescue Service (Chairman)
- nine Industry

The main functions of this Committee are to:

- Direct the MRS by formulating practical policies, procedures and strategies of the service provided;
- Determine the provision of appropriate training facilities, apparatus, equipment and training programmes;
- Prepare and update codes of practice, operational procedures, memoranda of agreement and physical requirements for rescue brigades;
- Consider and recommend major projects and budgets for approval by the Board of Directors.

The 142 mines in South Africa are serviced by four Rescue Stations:

- Carletonville (Head Office)
- Dundee
- Evander
- Welkom

These four stations are staffed with a complement of 38 people and provide a service for the 142 mines which employ approximately 600,000 people.

The MRS is run as a non profit organisation. The cost of manning the MRS is R5.5 million (approx. A$1.7M). The funding is raised via a levy on members. The levy is paid one quarter in advance:

60% on tonnes mined
40% on labour underground.

52% of funding is raised through sales to members and 48% raised through the Levy (subscription fees).

Fires and Incidents

In 1996, 1,235 teams were used which is substantially higher than the previous 5 year average of 857. The number fires and incidents (160) is also the highest in the last decade.

Rescue Brigade Strength 1,100 members

Rescue teams were involved in the recovery of 47 bodies resulting from underground accidents.

Final Meeting of the Australia/South Africa Coal Research Collaboration Visit on 21 April 1997 at CSIR Miningtek

Attendees as before.

The discussions held on the first leg of the research collaboration initiative were most rewarding. The results of these discussions on Escape and Rescue, Fires and Explosions, Pillar Design and common issues are discussed in the conclusions section of this report.

CONCLUSIONS

- The visit to South Africa was organised by the Mining Technology Division of CSIR (Miningtek). The visit was extremely well organised and catered for the three areas of research exchange in an excellent manner.
  The Australian party was of the unanimous view that the visit was of an outstanding nature and that exchanges of information and ideas would be invaluable to both the South African and Australian Mining Industries.
  The apartheid driven isolation has forced the South African industry to a level of self reliance not required in Australia and thus a research base more extensive than ours has been built on a much more sound financial basis. This leaves them in a much stronger position to cope with the loss of research and development technology from the US and Europe as their institutions are disbanded.
  The SIMRAC process differs from the ACARP process in that it is solely focussed on health and safety research and the funds are not subject to competition with production issues.
- In Escape and Rescue
  It was agreed that :
  Australia was more advanced in the following areas:
  - ⇒ early warning systems, both individual and mine-wide;
  - ⇒ gas monitoring systems;
  - ⇒ gas interpretation systems;
  - ⇒ competency based training
  - ⇒ re-entry protocols
  - ⇒

  South Africa was more advanced in:
  - ⇒ self contained self rescuers (SCSRs);
  - ⇒ guidance systems;
  - ⇒ integrated escape and rescue;
  - ⇒ change over stations/refuge bays; rescue vehicles;
  - ⇒ bore hole rescue

- SCSRs
  The Kinross disaster in 1986 in which 177 miners lost their lives was the catalyst that made the South African Government Mining Engineer introduce legislation requiring each person going underground in a mine to be equipped with a self-contained self-rescuer (SCSR). Since their introduction 531 lives have known to be saved by this technology.
  The Australian industry could benefit greatly from the South African experience with SCSRs. Monitoring programmes to assess performance and structural integrity of SCSRs in service should be implemented as the South African programme revealed adverse trends resulting in approval withdrawal on brands currently available in Australia. Defects detected on other SCSR models have resulted in improved versions being released.
- Mine Fires and Explosions
  It was apparent that -
  The South Africans have:
  - ⇒ good testing resources in Kloppersbos that do not exist in Australia.
  - ⇒ expertise in explosion suppression, both active and passive barriers.
  - ⇒ personnel experienced in the investigation of methane, coal dust and hybrid explosions.
  - ⇒ full scale testing facilities for investigation of dust suppression mechanisms on continuous miners and methane recirculation
  - ⇒ full scale testing facilities for investigation of ventilation patterns at active faces
  - ⇒ training materials and systems for educating the mine workforce in mine fires and explosions
  - ⇒ considerable experience in fires and explosions caused by sources other than spontaneous combustion.
  - ⇒ a considerable background in friction ignition.

  The Australian strengths were identified as :
  - ⇒ expertise in spontaneous combustion, both technical and in provision of training
  - ⇒ expertise in competency based training
  - ⇒ expertise in gas monitoring, analysis and interpretation, particularly the new generation gas chromatographs and the use of computers
  - ⇒ safety management planning processes
  - ⇒ the provision of technology transfer mechanisms
  - ⇒ active progression of external inertisation processes.
- Coal Pillar Design
  Prior to leaving for South Africa, a technology mapping exercise was undertaken with a range of researchers involved in coal pillar design in Australia. This mapping identified ten types of pillars used in coal mining and the issues needed to be taken into account when designing each type of coal pillar. These issues provided the basis for identifying future research and development needs in the Australian coal mining industry

A five and fifteen year target was identified for each R&D need.

The Australian technology mapping formed the basis for undertaking a similar exercise in South Africa. The South African exercise was complemented by discussions with researchers from a range of organisations supported by underground visits to four coal mines, one gold mine and one platinum mine.

- A continuing challenge of the South African mining industry is ensuring stable and safe excavations underground. In gold mining, rockbursts and rock falls continue to pose a major hazard to the safety of workers, particularly at the current and future depths where high rock pressures are combined with the aggravating effect of geological structures. More than 50% of fatalities and a large proportion of injuries result from rock related hazards - which often cause serious production losses.

  Australia and South Africa have very similar research needs in the following areas relating to coal pillars:

  High Priority
  - Pillar design tools
  - Effect of geology on pillar performance
  - Effect of time on pillar performance
  - Quantification of pillar loading systems

  Medium Priority
  - Effect of pillar geometry on caving conditions
  - Upper and Lower bounds of pillar design approaches
  - Rib control
  - Quantification of yielding pillar mechanics
- Possible joint ACARP/SIMRAC projects

  Complementary work which could be done in Australia and South Africa is as follows:
  - ⇒ what workers should wear on their belts;
  - ⇒ ergonomics of body-worn equipment;
  - ⇒ possibility of putting transponders on SCSRs so as to keep records on each device, and track the wearer;
  - ⇒ mine wide communication systems;
  - ⇒ explosion proof seals;
  - ⇒ replacement of long duration breathing apparatus.
- Other opportunities include:
  - ⇒ There was the need to investigate the sharing of unpublished information;
  - ⇒ Possible exchange of staff between the two countries in the three research areas should be considered.
  - ⇒ Fluidised bed combustion of coal discards was a potential area for collaboration.
- Escape and rescue

Experience in South Africa leads the world.

Approximately 600,000 people are employed in the South African minerals industry and over the last 8 years they have suffered 5,005 fatalities which is approximately 625 fatalities/annum. About 80% of these fatalities are in gold mines. Over the same period they have experienced 75,000 total injuries The MRS provides a service to 142 mines operating 4 stations with a permanent staff of 38 people. The MRS is to be congratulated on its effective, efficient and cost effective service to the mineral industry in South Africa.

Most mines in South Africa use rescue chambers for rescue escape. All coal mines use self contained O_2 self rescuers and rescue chambers for escape. However, in gold mines SCSRs are not compulsory.

Most mines use the O_2 self rescuers on the person with EBA 60 minute units outbye of the working area.

The advantages and disadvantages of rescue chambers were discussed. In an explosion the door of the chamber can be damaged so that people cannot get out or indeed gain access. Rescue chambers have been known to leak(!!) even though positive pressure is applied to the chamber.

The question of the dedicated intake airway approach was discussed. The South African rescue people liked the idea. With the first priority being men out of the mine if possible, men from their place of work to the rescue Chamber/Cache System, then to the dedicated intake airway.

The question is now to get the people from the working areas to the Rescue Chamber and the dedicated intake airway. The various methods - visual and sound - have been investigated and the South Africans have come up with the wire rope idea, from the working face to the Rescue Chamber or Cache system. The person at the working face hooks onto the wire rope which only works in one direction and then walks outbye to the Rescue Chamber/Cache System.

From discussions it became apparent that South Africa is a long way behind Australia in terms of gas monitoring and detection.

Some problems associated with ventilation, dust control and operator safety in mines visited were brought to the attention of the appropriate people concerned. This is an area that can be addressed without any research being carried out. We will assist the South African Team in this area during their visit to Australian Coal Mines.

RECOMMENDATIONS

The following ACARP/SIMRAC projects, with complementary work being done in Australia and South Africa should be pursued:

General Recommendations

- the research communities in both countries should develop closer ties and active communications;
- the potential for interaction and interchange of personnel should be pursued with vigour;
- the use of each others testing facilities should be investigated to ensure optimum use of existing resources and removal of unnecessary duplication;
- investigate the sharing of unpublished information

Specific Projects

- what workers should wear on their belts;
- possibility of putting transponders on SCSRs so as to keep records on each device, and track the wearer;
- mine wide communication systems;
- explosion proof seals;
- ergonomics of body-worn equipment;
- replacement of long duration breathing apparatus;
- face ventilation issues
- with regards to Escape in Australian Coal Mines the following procedure should be pursued:

⇒ men out of the mine if at all possible;

⇒ men from their place of work to the Cache System/Rescue Chamber; then onto the dedicated intake roadway and out of the mine.

- passive barriers with the research possibly being carried out at Lake Lynn (USA).
- Effect of time on life of pillars
- yield pillar and chain pillar design
- generic design pillar methodologies
- roof control

ACKNOWLEDGMENTS

The information contained in the conclusions and recommendations of this report is the result of discussions between the South African and Australian Team members. In particular, I would like to acknowledge the comments from my fellow team members, Professor Jim Galvin, Mr. Paul Mackenzie-Wood and Dr. David Cliff.

This report is an overview of the visit, and for more detailed information on the three subject areas the individual reports of my three colleagues need to be considered.