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Underground Coal Mining Safety Research - A Novel Canadian Initiative

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ABSTRACT: Since 1998 underground coal mine safety research in Canada has been spearheaded by the Underground Coal Mining Safety Research Collaboration (UCMSRC). UCMSRC is a collaborative "in-kind consortium" which brings together all of the principal stakeholders such as industry, labour, regulators, inspectors and universities, in jurisdictions where underground coal mining is active (Federal and Provincial - Nova Scotia, Alberta and British Columbia). The main goal is to contribute to improving safety and health in underground coal mining in Canada by collaboratively identifying and addressing related technology and knowledge gaps in key areas common to current/potential operating mines.

1 INTRODUCTION

The underground coal mining induFtry in Canada is small and geographically wide spread. Individual compani.j operate only one or two mines; the economies of scale that allow for large research budgets are absent. In addition, mining conditions are often difficult, and markets cyclical.

Over the last four decades, health and safety-related research in underground coal mining in Canada has been typically carried out by the operating companies through a combination of in-house expertise and specialist contractors and consultants with significant technical and financial support from the Federal Government.

The latter input has primarily been provided through the Mining & Mineral Sciences Laboratories (MMSL) of the Canada Centre for Mineral & Energy Technology (CANMET) of the Federal Department of Natural Resources, Canada (NRCan, formerly Energy Mines & Resources). Between 1982 and 1998 the Cape Breton Coal Research Laboratory in Sydney, N.S. spearheaded government investment in coal mine health and safety issues.

CANMET's research directions continue to evolve in response to changing needs of clients - both external and internal clients. In a major programme change in 1998 the CANMET Coal Mine Health and Safety programme was shut down because the industry could no longer provide the funds required to maintain cost-sharing quota's. However, following consultation with indubiry stakeholders, CANMET began a new research initiative in this area, known as the Underground Coal Mining Safety Research Collaboration (UCMSRC).

This paper outlines in turn the background, development, establishment, key features, initial progress and potential future development of this new research initiative.

2 UNDERGROUND COAL IN CANADA

Coal mining in Canada began on Canada's east and west coasts. In the east, the first recorded mine was at Grand Lake, New Brunswick in 1639. In the west, coal mining began in 1836 on Vancouver Island, British Columbia. As the railroads moved west from central Canada in the late 1800s, mining spread to eastern British Columbia, Alberta and Saskatchewan.

During the first half of the twentieth century half of Canada's energy needs were supplied by coal. By 1960, however, petroleum products (crude oil and natural gas) had replaced coal as the energy source of choice and coal's share had dropped to 20 per cent.

The change happened so rapidly that coal-mining communities found themselves facing mine closures and job losses if they could not find a new market for their product. Many of them could not and in many places coal mining, especially underground coal mining, all but disappeared.

The coal industry began a comeback of sorts as oil price rises and strong demand for metallurgical coal in the Pacific Rim allowed producers to exploit these markets. In 1960, Canada mined 11 million tonnes of coal. In 1979, it mined 33 million tonnes. In 2001, production stood at over 70 million tonnes. However, almost all of this coal was surface mined, with the exception of underground mines on Cape Breton Island, on the Alberta / British Columbia border and on Vancouver Island.

In the last decade, underground coal mining was restricted to the offshore deposits in the Sydney Coalfield of Nova Scotia (undersea longwall retreat mining), a room and pillar underground operation at Grande Cache in the Alberta Rockies, and an underground room and pillar mine at Campbell River on Vancouver Island off Canada's west coast.

In 2000, the Alberta mine went into liquidation as a result of high debt and low coking coal prices. The mines in Nova Scotia, run as a Federal Crown Corporation, closed in 2001 as the Federal Government determined that the operations were no longer economically viable. In 2003 there was only one operating underground coal mine in Canada, at Campbell River on Vancouver Island.

2.1 Future Prospects

Despite the bleak recent history, the future looks more promising for the underground coal mining industry. Several years after the closure of the Cape Breton underground mines, the Provincial Government is offering the remaining viable coal leases to interested parties. There is the possibility of at least one undersea underground coal mine being established.

In Alberta, a new underground room and pillar operation producing coking coal at Grande Cache obtained government approval and began work in 2004. In north eastern British Columbia at least one company has developed plans for combined surface and underground operations to tap low ash coking coal reserves, although such projects are still in the early stages.

Even with these new opportunities, however, the Canadian underground coal mining industry is small by any standards, presenting significant challenges to the regulatory bodies.

2.2 The **Canadian** Coal **Mine Safety Regulatory Infrastructure**

In Canada, individual Provinces and Territories have autonomy over a number of social areas, including occupational safety and health and the regulation of mineral resource extraction. Each Province and Territory has its own mines safety program, and conducts safety inspections to ensure compliance. Provincial Mines Chief Inspectors meet annually, and there are Provincial Eastern and Western regional Mine Rescue Competitions.

The Federal Government oversees national issues, such as defence and foreign policy, but also retains regulatory and safety inspection powers over its own employees and a number of other industries. Until recently the underground coal mines that were worked by Cape Breton Development Corporation (CBDC), a Federal Crown Corporation, fell under a Federal Coal Mines Safety Act and inspection service.

Nova Scotia repealed its coal mining regulation Act in 2003 and new mine regulations came.into effect in November 2003. The regulations are essentially prescriptive in nature, and as well as establishing qualifications and duties, set out rules for the use of explosives, electricity, diesel equipment and the like.

British Columbia has a single mines safety code which includes sections relating to underground coal mines. Again, the code is largely prescriptive in nature. The province reviews and updates this code every four to five years, with the last update completed in 2003.

Alberta is the only other Province with specific underground coal mine regulations. Very recently the Province completed a major overhaul of all Occupational Health and Safety legislation which replaced most industry specific regulations under the OHS Act with codes of practice. The mining section of the code of practice varies little from the previous regulations, but the general code now includes a requirement for hazard assessment of all workplace tasks, although risk assessments are not recognised.

Coal mine safety inspection services in all three provinces are limited. In the absence of any working underground coal mines in Nova Scotia the complement of inspectors and support staff is small and inspections are limited to a small number of surface mines and non-coal underground mines. In British Columbia two Provincial employees have underground coal mining experience and qualifications, one of whom is directly responsible for compliance, although the staff resource base is somewhat larger as British Columbia also has operating underground hard rock mines. In Alberta, mines inspection is contracted out. At present, the underground coal mine inspector, the electrical inspector and mechanical inspector are semi-retired consultants based out of Calgary, but actually resident in neighbouring British Columbia.

2.3 Underground Coal Mine Safety Research and Development

Canada was founded on its rich natural resource base, so it is not surprising that the Federal Government established an oversight department to assist m the development of technologies and techniques to maximize the benefit of these resources to the nation Natural Resources Canada (formerly Energy, Mines and Resources) - CANMET (Canadian Centre for Mineral and Energy Technology) has played a significant role in mine technology and mine safety in both coal, hard rock, and salt/potash mining in Canada

CANMET has historically been active in underground coal mine research The Western Laboratory, with offices in Edmonton and Calgary, Alberta, was involved m ground control and subsidence research in underground coal mines, coal preparation and oil sands in western Canada, and also initially conducted work m the east In the late 1970's, during the resurgence of interest in coal, Alberta with support from the Coal Association of Canada and the Federal Government established its own Provincial facility, the Coal Mine Research Centre, which also involved itself in strata control and mining technology

In 1979 a fnctional ignition at CBDC's No 26 Colliery in Glace Bay resulted m a methane explosion that killed 12 miners Acting on the recommendations of the inquiry into the accident, CANMET established the Cape Breton Coal Research Laboratory (CBCRL) m 1982 With 15 scientists and support staff, it conducted safety and health related research into ventilation, strata control and mining methods for 16 years, mostly in eastern Canada, but also in the west when required, supporting the CANMET Western Research Laboratory

CBCRL provided a catalyst for safety research in the Canadian underground coal mining industry through comprehensive joint collaborative research programs with the mining companies Through research contracts it maintained underground coal mining expertise at university mining schools and consulting firms In 1992 they provided support services to the mine rescue operations after the explosion at Westray Mine

However, national concern over the rising level of public spending m the mıd-1990's lead to large cuts in budget across all of the cıvıl service CANMET was identified as a "service" department that could assist in its own financing by performing "cost recovery" work Unfortunately, the small size of the underground coal mining industry could not support CBCRL to the desired amount, and it was closed in 1998, shortly before the closure of the CBDC mines

3 DEVELOPMENT OF UCMSRC

The Federal Government's 1995 Program Review within CANMET involved a business case evaluation of all programs CANMET s Cape Breton Coal Research Laboratory (CBCRL) in Sydney, Nova Scotia was re profiled as a research program known as the Coal Mining Health & Safety Program (CMHS) A 3-year plan to attain financial self-sufficiency was established in 1996 and reviewed m late 1997 when it was reluctantly recognized that, with a small client base, recent strong performance was clearly not sustainable m the long term It was announced in February 1998 that CMHS and hence the CANMET Sydney Laboratory should cease operations in March 1998 However, CANMET made clear their desire to stay active in this research area

In the summer of 1998, CANMET approached CMHS stakeholders for their ideas on how CANMET could continue to meet their technology research needs in this field A questionnaire was sent to 22 stakeholders including operators, inspectors, regulators, researchers (government, private, universities) These stakeholders represented all the jurisdictions involved in underground coal mining Federal, Alberta, British Columbia & Nova Scotia Of the 13 responses received, 11 were supportive Workplace safety and health remained important factors in underground coal mining and there was strong support by the stakeholders for CANMET to continue collaborative research in underground coal mining safety

A draft agreement, including work plans for the initial project areas, was prepared and circulated to stakeholders for consideration It was finalized as a Memorandum of Understanding (MOU) for UCMSRC on September 24, 1998 Seventeen stakeholder organizations signed the MOU to become participants in UCMSRC, with 2 other organizations requesting a continuing role but as Associate Members (without voting privileges) The participants include operators, labour, regulators, inspectors and university researchers, across four jurisdictions (Federal, Nova Scotia, Alberta, British Columbia) The MOU outlined the basic details of what the UCMSRC was about, how it would work, how it was to be funded and what was required of participants

The MOU has since been renewed several times However, in order to facilitate those stakeholders/participants who were unable to sign the MOU due »j "legal" concerns, a simplified Letter of Undersf idmg (LOU) was prepared for the period October 1, 2003 to September 30, 2004 to replace the MOU The LOU is renewed for each subsequent year

Committed to constructive dialogue and project implementation, participants benefit from dialogue with others involved in the underground coal mining industry across Canada, and from participating in project selection and research work, also sharing the findings of the research

4 KEY FEATURES

4.1 Structure and Operation of UCMSRC

The purpose of UCMSRC is to provide a forum for dialogue and research involving stakeholders in Canadian jurisdictions where underground coal mining is active The main goal is to contribute to improving safety and health in underground coal mining in Canada by identifying and addressing related "gaps" in technology and knowledge in key areas common to current/potential operating mines

The organizational structure is relatively simple An Executive Committee, consisting of three representatives from CANMET (the Chairperson, Secretary and Technical Advisor, the chair having the casting vote) and one member from each participating organization, is responsible for all decisions on direction, management and control, including discussion, selection and approval of projects and the people to work on them

A Technical Forum Committee, comprising the three CANMET representatives (who are responsible for minutes, documents, liaison and coordination of day-to day activities), at least one member from each of the participating stakeholders and a Technical Advisor discusses technical issues and coordinates project proposals and directions at regularly scheduled meetings It also coordinates project teams and provides guidance for new projects that are approved by the Executive Committee The Executive Committee and Technical Forum Committee meetings are usually held together in an effort to make the most effective use of participants' time

Finally, project teams are formed as necessary to carry out each project All project team leaders and members are approved and appointed by the Executive Committee (and may include participant staff who are not on the Executive Committee) Project teams carry out the work and communicate via conference call and electronic media, formally reporting progress to the Executive Committee on a regular basis

The prime means of communication is by telephone conference call Typically participation in the collaboration involves commitment of less than 1 day per month of participants' time, plus one visit per year to a 'round table' meeting

The Executive Committee strives to reach consensus on all matters In the event of an impasse, decisions are made by a simple majority of those present, with the chair having the casting vote Also, any approved project work involving work at a mine site will also require prior written approval from the operating company

The Technical Advisor facilitates the on-going technical work These duties include

- the preparation of a 'Technical Discussion" document for each meeting in which the latest technical information and news from the underground coal mining industry worldwide is summarized for the UCMSRC participants, with input also from the three CANMET representatives
- technical advice to the UCMSRC
- editing of technical papers undertaken by UCMSRC participants
- preparation of technical papers/information as directed by the UCMSRC

4.2 Resources & Funding

For the first 5 years there were no cash contributions/payments required from participants except CANMET UCMSRC relies on in-kind contributions from all participants to ensure the work (as defined for projects approved by the Executive Committee) can be achieved

CANMET provided not only in-kind resources to support up to 2 full time position equivalents and appropriate administrative costs but also provided direct financial resources to support up to 3 postgraduate students across the three provinces and direct financial support for a technical advisor ($2'">k per year)

The in-kind contributions include provision at no cost to UCMSRC of the following appropriate time of staff and administrative support services, materials, equipment and approvals (e g in the case of any in mine work), and travel, accommodation expenses (for example, to attend occasional in person meetings)

Unfortunately, due to reduced CANMET - MMSL budgets, direct funding for UCMSRC was ended in September 2003 Despite the lack of direct funding, CANMET - MMSL continues to support UCMSRC by providing up to 2 full time position equivalents, maintaining the "secure" ugcoal ca web site, and covering appropriate administration costs, amongst other things

With this reduction in CANMET funding, UCMSRC has looked to alternative sources of funding In the fall of 2003 the three provinces (Nova Scotia, Alberta and British Columbia) where there is underground coal mining were approached Each province was requested to contribute $7,500 Nova Scotia and Alberta each contributed $7,500 for a total of $15,000 on a "one-time" basis

How to obtain future funding continues as an important issue with UCMSRC and various avenues are currently being explored Given the expertise of Canadian coal operators in steeper seams, and in both longwall and room and pillar mining methods, as well as the extensive background in health and safety aspects, one option being explored is to expand the work of the UCMSRC to include overseas components

5 PROJECT WORK

5.1 Project Selection

The Executive Committee seeks projects with significant potential impact, e g on safety and also on production and/or resource utilization, and with as wide as possible support from participants The following project selection and approval criteria apply

- a project topic/subject must relate to the improvement of safety and health of either active or potential underground coal mine operations in Canada and preferably also have potential significant impact
- a project should be agreed to by as wide as possible a support base across the participants, and ideally should be agreed to by the operators from all three provinces and by at least one other participant in each province

The collaboration has produced a significant body of work, considering the limited funding available

5.2 Geotechnical Review of Canadian Coalfields

Funded by CANMET and by the mining companies operating at the time, this project was aimed at evaluating the geotechmcal conditions existing in the major Canadian underground coal mining areas and describing standard methods for geological and geotechmcal assessment purposes

UCMSRC produced two separate reports which described the geological setting of the three major underground production areas and sought to standardise geological and geotechmcal assessment between the various mines Additional input and rock testing services were provided by CANMET staff

5.3 Explosion Protection

Explosion protection in underground coal mines is an emotive issue m Canada, with strong opinions held on a wide range of subjects by all industry stakeholders It was an explosion at No 26 Colliery at Glace Bay, N S That provided the impetus for the establishment of CANMET's Coal Mme Health and Safety program, and the repercussions of the explosion at Westray Colliery in Stellarton, N S In the early 1990's are still being felt through the industry

A number of topics relating to explosion protection have been covered as joint projects by UCMSRC members, including

- a review of hazardous location zoning regulations in Canada and elsewhere as it pertains to the location and type of electrical equipment used underground, completed by CANMET staff at the request of UCMSRC stakeholders
- a review of the regulations dealing with the cutting off of electrical power during periods of elevated methane concentrations, particularly addressing the methane levels initiating cut-off in Canada and elsewhere, also completed by CANMET staff at the request of UCMSRC stakeholders
- a literature review of recent research into passive and triggered explosion barriers in underground coal mines, funded by CANMET and performed by Dalhousie technical University staff
- a review of international practise relating to the use of stone dust to control explosions, completed "pro bono" by members of the UCMSRC

5.4 Canadian Underground Coal Legislation Review

Currently ongoing is a study aimed at identifying the similarities and significant differences between four separate underground coal mining health and safety regulations (codes) currently in operation in Canada This work, when it is complete will, it is hoped, provide a basis for the rationalisation of coal mining legislation in the country, although ultimately it is up to the individual regulators if they choose to take any notice of the results

5.5 Literature Reviews and "Fact Sheets"

Members of UCMSRC, and contractors paid out of UCMSRC funds, have prepared literature reviews on several important subjects on behalf of the group These include

- A List of International Expertise in Health & Safety in Underground Coal Mines
- Approved Explosives and Explosive Detonators for Use m Underground Coal Mines
- The Use of Fire Resistant Fluids in Underground Mining Equipment
- Explosion Proof Stoppings in Underground Coal Mines
- The Use of Refuge Stations in Underground Coal Mines

"Fact Sheets" are two or four page summaries of the results of UCMSRC investigations, presented m a point by-point format for easy reference, along with major references to the information covered These fact sheets are published as web-browser compatible documents, and once approved by the Executive Committee for publication are available to the public

Fact sheets currently available include

- Fact Sheet on the Use of Light Metals & Their Alloys in Underground Coal Mines
- Fact Sheet on the Use of Stone Dust to Control Coal Dust Explosions in Underground Coal Mines

5.6 Other Activities

Other activities in support of the UCMSRC include the preparation of a quarterly Technical Review of the industry, which includes overseas and Canadian news and developments summarised from a variety of sources This document serves a technology gatekeeping role, providing members with an overview of developments around the world

The UCMSRC operates two web sites A secure web site, allowing password protected access by members to meeting agenda's, minutes and notes, as well as reports and other documents, is hosted by CANMET The secure website is accessed through a public portal, which allows members to reach the secure site, and the public to access published information This website, www ugcoal ca, is hosted by one of the UCMSRC participants

6 CURRENT ISSUES IN UNDERGROUND COAL MINE SAFETY AND HEALTH.

The underground coal mining industry in Canada is now small and geographically widespread With the current heating up of markets for western coking coals, and the release of leases in Nova Scotia, there is reason to hope that a small revival may take place The current issues in underground coal mine safety and health are summarised below

6.1 Multiple Safety Codes

Four different safety codes (Federal and three provinces) co exist within the Canadian underground coal mining industry

While this is easy to understand in a political context, it has the effect of complicating the industry by restricting the mobility of equipment and manpower between provinces This merits activity towards harmonizing regulatory issues and developing national industry competency standards for employees and officials to achieve improved efficiency and cost effectiveness

6.2 Declining Personnel

Each Province must somehow provide inspection expertise m ventilation, electricity, strata control, subsidence, mechanical engineering and general mine safety from a dwindling resource base Consultants from overseas can offer some relief, but few can offer experience m the conditions encountered in Canada

The small size of the Canadian underground coal industry is unlikely to encourage the required recruitment into these areas or provide suitable development opportunities for junior staff to maintain an acceptable level of expertise for inspection duties This warrants more inter-jurisdictional activity to maintain core resources and enhance response to any resurgence in underground coal activity

Harmonization of regulatory issues and competency standards will assist in this, as would the development of a national resource base of competent inspectors and consultants on specific issues, who could then potentially be shared between Provinces

6.3 Future Mining Needs

New underground coal mines in Canada are likely to be developed in mining conditions that push the limits of conventional mining methods.

The major potential underground coal resource in Nova Scotia is some 3.5 km offshore. Previous operators drove two tunnels to the coal seams which are now flooded and abandoned. Any kind of mining at this distance from the surface raises safety issues around subsidence and water inflows and emergency egress.

In Alberta, the majority of the remaining coking coal resources are in steep, thick seams. Non-conventional mining methods require considerable additional research for them to be safe and successful.

Mining in these conditions is foreign to most of the world's coal mining community. Competent extraction and inspection personnel are few and far between. There is a need to grow these competencies within the Canadian context to support the underground coal mining industry as it begins to exploit these reserves.

6.4 Research Funding

The small size of the underground coal mining industry does not attract significant research funding into underground coal specific safety issues. The slim financial margins of the producers do not allow for much in the way of proactive safety and health research. But in a climate of largely prescriptive legislation, what impetus is there for spending money on finding new and safer ways when the legislation you work under already sets minimum standards?

UCMSRC currently addresses this by allowing its members to identify key safety issues, and then using such resources as it has available, mostly time volunteered by its members, to understanding and resolving them. However, in most instances limited additional funding restricts the UCMSRC approach to reviews of current practice overseas.

7 DISCUSSION

In some ways the downsizing and uncertainty over the future of the underground coal industry in Canada in the last few years has strengthened the need for closer communication and cooperation between the remaining underground coal mines and other stakeholders. Born out of severe funding cutbacks felt across the Canadian scientific civil service, UCMSRC has provided a valuable forum for the few underground coal mine industry stakeholders that remain.

That isn't to say that all members share the same ideas; there is almost as much variation as there are members. However, although they may differ in the means of achieving it, each of the members, and the organisations they represent, are committed to ensuring the health and safety of underground coal mine employees.

It is this commitment that ensures the success of UCMSRC and allows members with competing interests to work together on joint projects for the benefit of everyone concerned. Coming from a nation known for almost excessive politeness and recognised international service as an arbitrator and peacemaker, it isn't surprising that this uniquely Canadian approach is enjoying some success.

The four key issues identified as taxing the future development of the Canadian underground coal mining industry, namely competing regulations, intellectual resources, future mining needs and the funding required to address these issues are subjects of active (and often intense!) debate within UCMSRC, which continues to apply itself to facilitate this dialogue and to ensure a supportive environment for any future resurgence of underground coal mining in Canada.

The medium-to-long-term outlook for underground coal mining in Canada has improved somewhat in the last year, largely due to an unforeseen rise in demand for the same metallurgical coal which stimulated a Canadian coal mining resurgence in the early 1970's. Substantial safety and health challenges will be raised as the industry expands.

Subject to obtaining the small amounts of funding required to maintain its activities, UCMSRC has the flexibility to develop further projects as the need arises, primarily through the Technical Forum meetings, but the issue of resources and their application to the challenges presented still remains.

There are two possible solutions. The first is to charge a significant membership fee to participants to guarantee them access to the work produced, and to sell UCMSRC reports to non-members. This, however, may actually result in a reduced membership and hence less resources in the long run.

The second option is to encourage wider, potentially international, participation in UCMSRC on a no-fee basis. However, this might require changes to the operational methods to overcome time zone differences between participants. A third option might be an expanded membership and a nominal fee.

In the interim, however, UCMSRC will continue to provide the only Canadian national forum for health and safety related issues in the underground coal mining industry.

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While acknowledging the assistance and support of UCMSRC members, the author takes sole responsibility for any opinions expressed above, and notes that opinions expressed may not be shared by other members of UCMSRC or the organisations they represent.

Permission to present this paper was obtained from the Executive Committee of UCMSRC.

Finally, thanks are due to the IMCET organising committee for the opportunity to share this work with conference delegates.

9 REFERENCES

All of the publicly available documents discussed above are available for download from the UCMSRC website, www.ugcoal.ca.

Additional information on any of the subjects can be obtained from the site webmaster, or from any of the authors at the email addresses given above.

Challenges and Criticisms of ISO 14001 Certification of Two Asbestos Mines

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ABSTRACT: The adverse health effects of asbestos are undisputable and well documented in mining environmental literature. The worldwide environmental anti-asbestos campaign begun in the late-1980s is premised on this fact. Consequently, major asbestos consumers like Japan, United States and most of Europe will completely ban the use of asbestos by 2005. Most asbestos mines have responded to this challenge by maintaining, reducing or ceasing production thus, portraying the industry as a sunset industry.

Anticipating closure, African Associated Mines (AA Mines) took a bold step to develop and implement an ISO 14001 Environmental Management System (EMS) to minimise environmental liability at closure through improved environmental performance. The EMS was certified in February 2004 and apart from initial intentions, it enabled AA Mines to establish new asbestos markets in the Far East. This paper examines the challenges and criticisms of the certification process of AA Mines.

1 INTRODUCTION

African Associated Mines (AA Mines) is the sole producer of chrysotile asbestos fibre in Zimbabwe. The company is one of the single largest mining employer and foreign currency earner in the country, employing close to 6,000 employees (about 10% of the total formal mining labour force in the country). AA Mines produces a total of about 145,000 t/year of chrysotile asbestos fibre from its two subsidiary mines, Shabanie and Gaths. Shabanie mine is located in Zvishavane about 180 km south-east of Bulawayo, the country's second largest city and Gaths Mine is located in Mashava a further 60 km to the east of Zvishavane (Figure 1). The two mines are both underground mining operations utilising sub-level and block caving methods for ore extraction from Archean schist rock formations. The ore from underground is sent for processing at the milling plants where the fibre is extracted from the rock by crushing and selective vacuum aspiration. The fibre is then cleaned and blended into various grades as per customer specifications and then packaged for shipment. In February of 2004 the two mines were certified to the international ISO 14001 standard. The certification was achieved amid several challenges and criticisms.

2 CHALLENGES AND CRITICISMS

The first challenge was that the certification was sought at the height of a strong world environmental anti-asbestos campaign begun in the late-1980s for asbestos-related respiratory and cancer diseases. Accordingly, major asbestos consumers like Japan, United States and most of Europe will completely ban the use of asbestos by 2005. Admittedly, the adverse health effects of asbestos associated with its uncontrolled production and use are undisputable and well documented in mining environmental literature (Asbestos International Association, 1990; Bignon, Peto and Saracci eds., 1989; Dement, 2001; Virta, 2002; World Health Organisation, 1986 and World Health Organisation, 1989). The campaign has been quite strong forcing most producers to maintain, reduce or cease production resulting in an overall declining world production (Figure 2). As can be seen from Figure 2, world annual asbestos fibre production declined from 4 million tonnes in

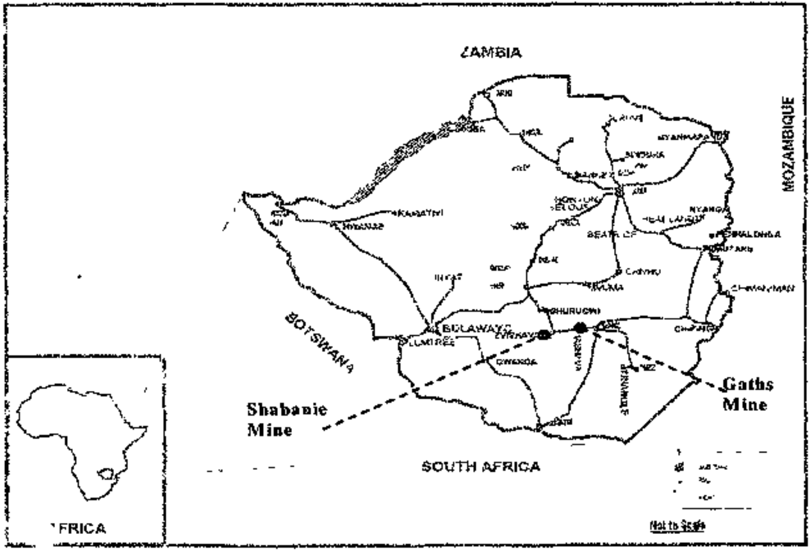


Figure 1. Map showing location of Shabanie and Gaths mines.

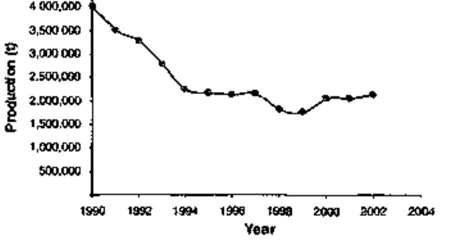


Figure 2. World Asbestos Production from Î 990

(Djt j Source'BııckıııgllümaiKİ Vırt a, 2004)

1990 to stabilise around 2 million tonnes from the year 2000.

Secondly, there was no local mine to draw experience from since the mines were among the first mines in the country to pioneer the ISO 14001 route. There was also the general perception that mines were not very environmentally conscious as evidenced by the numerous media reports on mine accidents and disasters.

AA Mines also faced the criticism that they had chosen the ISO 14001 route because they wanted to improve the marketing of their product not that they genuinely wanted to improve their environmental performance. Thus, by implementing ISO 14001 Environmental Management System (EMS), the mines needed to prove that their environmental performance had indeed improved.

The certification was also achieved at a time when the ISO 14001 standard has been receiving widespread criticism that it is not a panacea for environmental problems. The paradigm shift away from the perception of ISO 14001 as an effective environmental management tool has resulted in serious debate between two schools of thought. In one school are the advocates of ISO 14001, who argue that it is a product of international consensus and a comprehensive tool that provides industry with a way of controlling environmental impacts (Krut and Gleckman, 1998). The proponents also strongly argue that ISO 14001 provides access to global markets and is likely to become a condition for doing business globally. In the opposing school are the critics who argue that ISO 14001 on its own is an inadequate tool to solve environmental impacts of industry (Krut and Gleckman, 1998). Firstly, they argue that it limits public involvement since the public cannot set targets or monitor industry's performance. The targets are set by the industry themselves and are what they are judged against. Also ISO 14001 is voluntary, thus companies are not obliged to disclose environmental performance results making it difficult to know their environmental performance (McCreary, 1996). Another argument is that ISO 14001 alone cannot be used to distinguish between a good and a desultory environmental performer, thus companies with "weak" environmental policies who could be seriously polluting the environment could easily get certified

One technique for investigating the environmental impact of a particular product is its full Life Cycle Analysis and Management (LCA) LCA uses a systems approach to investigate the inputs and outputs during each stage of a product's production, use and disposal Critics of ISO 14001 have argued that LCA should be the basis for assessing environmental performance rather than site-based polices and audits characteristic of the ISO 14001 EMS In response to these criticisms some countries such as Denmark and Sweden, have adopted an "ISO 14001 Plus" approach, requiring companies to fulfil the ISO requirements plus additional demands specific to their product

Given the foregoing arguments, the rest of this paper examines how the challenges and criticisms of ISO 14001 certification have been addressed by AA Mines The discussion analyses and reviews the core elements of ISO 14001 EMS and the AA Mines experiences relating to each element The five core elements of the ISO 14001 standard are

- An environmental policy,
- An assessment of environmental aspects, legal and voluntary obligations,
- A management system,
- A series of periodic audits and reports to top management and
- A public declaration that ISO 14001 has been implemented

3 ENVIRONMENTAL POLICY

An environmental policy statement is the only public document that the ISO 14001 standard requires a certified organisation to produce The main role of the policy statement is that it is the basis for the design, implementation, monitoring and continual improvement at a certified facility In order to guard against the criticism of producing a "weak" environmental policy, AA Mines undertook a comprehensive "initial review" to establish the environmental status of the organisation After benchmarking the status against regulatory, industry and company voluntary standards, a policy statement was produced that outlined the company's commitment to prevention of pollution with emphasis on

- Air-borne asbestos fibre and rock dust,
- Air, water and land pollution,
- Noise and vibration levels,
- Dumps rehabilitation and management,
- Accident and incident prevention,
- Identifying and eliminating any possible environmental and health risks and
- Conservation of resources

4 ENVIRONMENTAL ASPECTS, LEGAL AND OTHER OBLIGATIONS

The ISO 14001 standard requires an organisation to conduct performance assessment In setting objectives and targets, an organisation should "establish and maintain procedures to identify environmental aspects of its activities, products or services that it can control and over which it can be expected to have an influence " (SAZ, 1996) In addition, an organisation should establish and maintain a procedure to identify and have access to legal and other requirements to which it subscribes (SAZ, 1996) Twenty legal and other relevant instruments were identified by AA Mines (Table 1)

Table 1 List of legal and other relevant instruments

1 Mines and Minerals Act (Chapter 21 05) (1996)
2 Mine (Management and Safety) Regulations (1990)
3 Explosives Act (Chapter 10 05) (1996)
4 Natural Resources Act (Chapter 20 13) (1996)
5 Hazardous Substance and Articles Act (1996)
6 Forest Act (Chapter 12 05) (1996)
7 Water Act (Chapter 20 24) (1996)
8 Atmosphere Pollution Prevention Act 20 03 (1996)
9 Parks and Wildlife Act (Chapter 20 14) (1996)
10 National Museums and Monuments Act (1996)
11 The Pneumoconiosis Act (Chapter 15 08) (1996)
12 Environmental Management Bill (2000)
13 Public Health Act (Chapter 15 09) (1996)
14 Explosives Regulations (1989)
15 ILO Convention 162
16 Urban Councils Act
17 Labour Relations Act
18 Road Traffic Act
19 ZINWA Act
20 Workman s Compensation Act

The initial review and benchmarking process established that the most significant environmental aspects were, in order of priority

- Air-borne asbestos fibre,
- Air-borne rock dust,
- Fumes from explosives blasting,
- Noise from machinery and equipment,
- Vibration from machinery and equipment,
- Exhaust fumes from mobile equipment,
- Oil spillage from mobile equipment,
- Waste rock and fines and
- Heat from virgin rock and mobile equipment

Although legal compliance was already being achieved in most of the significant aspects, EMS targets were set to operate well below the compliance limits Accordingly, operational procedures were developed to ensure compliance with EMS targets Relevant operational control and monitoring programmes were then developed to ascertain the adequacy of these procedures in meeting the required EMS targets As will be seen later, if a procedure was failing to give required results, it was reviewed and amended so that it improved the control of the significant aspect concerned Air borne asbestos fibre and rock dust look top priority on the significant aspects register since they are directly the causes of the adverse health effects of asbestos It is for this reason that although the performance on other significant aspects were controlled and monitored, only the performance in controlling these two will be reported here In addition only the two major departments, mining and milling, that liberate fibre and dust into the air will be reported on The legal limits set out in the Mine Management and Safety Regulations of 1990, for air-borne asbestos fibre and rock dust, are 2 fibres per millilitre per 4-hour period and 10mg per m^3 per 4-hour period, respectively Since the mines were already achieving fibre and dust counts below these legal limits, it was agreed that the sampling locations and number of personal samplers would be maintained The air borne fibre EMS target was then set as the percentage of samples with fibre counts greater than 0 5 fibres per millilitre per 4-hour period being less than 5% of total samples, within three years and thereafter to 0% For rock dust counts, the percentage of samples with dust counts greater than 8mg per m^3 per 4 hour period were to be within 5% of the total samples, again within three years The ISO 14001 programme had been started at the end of June 2001 (i e Quarter 3, 2001) and the compilation of the procedures was completed in Quarter 4 of 2001 Implementation of* the procedures began in Quarter 1 of 2002 and ran * for 2 years before certification (i e Quarter 1 of 2004) The results of the implementation are shown in Figures 3 6 Figure 6 is typical example where a procedure had to be amended to improve the control of dust in the milling plant at Gaths mine The results show that, although there were variations from Quarter to Quarter, the general trend was a gradual decline in the percentage of samples above the set target It can also be seen that before project implementation the variations were more erratic compared to the period during implementation and after certification, indicating the impact of action programmes Similar trends were established for other significant factors, other than fibre and dust It can be concluded therefore, that AA Mines' environmental policy led to improved environmental performance in key target areas, hence the granting of the certification

5 MANAGEMENT SYSTEM

The established environmental management system checks if an organisation is in line with its stated environmental policy Through clear lines of authority and responsibility, an EMS follows project cycle phases of planning, implementation, monitoring, corrective action, review and continual improvement At AA Mines, an ISO 14001 team comprising of carefully selected departmental representatives headed by a management representative, the Technical Services Manager, was mandated to drive the programme semi-autonomously at departmental level so that chances of carrying over the existing status quo were minimised The departmental heads also had to commit themselves to complying with the ISO 14001 programmes specific to their sections It was also realised at the onset that the participation, and more importantly, acceptance and ownership, at grass roots level were essential for a successful ISO 14001 project Thus, the mine launched a 'Come on-Board' programme to educate employees on the importance of their participation and ownership of the ISO 14001 project This approach was quite effective in getting the EMS through various the project phases The associated documentation generated by the EMS at AA Mines included the following

Environmental Health and Safety (EHS) Policy,

EHS Policy Manual,

Legal Aspects Register,

Significant Aspects Register,

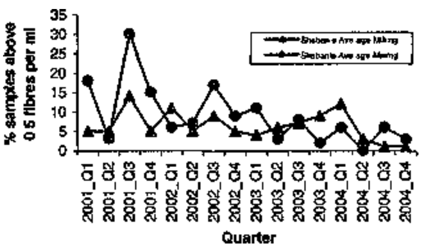


Figure 3 Fibre Count Trend for Shabame

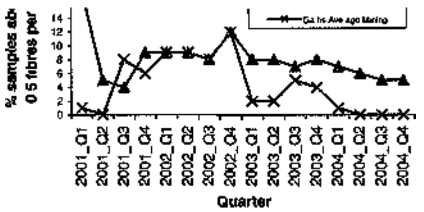
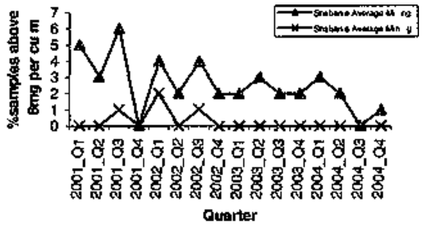
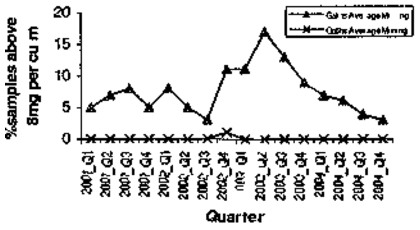


Figure 4 Fibre Count Trend for Gafhs Mine





Figurée Dust Count Trend for Gaths Mine

- Proceduies Manual,
- Work Institutions Manual and
- Records

6 PERIODIC INTERNAL AUDITS

Internal audits are undertaken to veufy if the EMS is conforming to action plans and policy Results of audits are reported to top management In addition to internal audits, an organisation seeking certification will have to be audited by an accredited external third party Clitics argue tliat ISO 14001 is based on internal and external audits, whose ıesult is piesented to senior management It is not clear if information discovered during an audit shows illegal activities or major pollution can be disclosed to the public or ıegulatory authorities as the consequences could be heavy lawsuits and lengthy litigations (McCreary, 1996) The standard does not state if regulatory authorities can demand access to audit results

In the case ot AA Mines, all the four internal audits undertaken prior to certification did not reveal majoi non regulatory compliance In addition, the fust SAZ third party audit only picked up minor non-conformances which were rectified during the three months befoie the final certification audit in Febıuaıyof2004

7 PUBLIC DECLARATION

The ISO 14001 standard requires that the environmental policy should be communicated and made available to the public AA Mines met this requirement by publishing the policy it was implementing m the local media and soliciting inputs into the progiamme It also communicated later through the same local media that it had attained ISO 14001 certification

8 OTHER ISO **14001** BENEFITS

Over and above improving the mines' production environment, part of the EMS entailed the development of a good mine closure plan The closure plan included projects that could ıesult m former asbestos dumps being cleaied away for use as raw material tor the production of other environmentally safe products These projects, still in their embiyomc stages are the recovery of magnesium from dumps, conversion of the dump matenal to pioduce low temperature Chiome-Mag foundry bricks and the ıecoveıy of nickel from the dumps These projects were the results of an ISO 14001 driven mind set change from traditionally viewing piocess waste as "waste" to viewing the same waste as possible raw material foi other processes that can be developed

9 CONCLUSION

AA Mines developed and implemented an ISO 14001 EMS in anticipation of closure so that environmental liability at closure would be minimal However, after certification, the mine was faced with a pleasant surprise as closure was no longer imminent since the piocess had led to the establishment of new markets. In addition, environmental performance improved AA Mines are likely to continue improving their environmental performance so that they do not lose the certification in subsequent surveillance audits This project was a huge task the mines undertook against a backdrop of serious challenges and criticisms These included criticisms on the inadequacy of ISO 14001 as an effective environmental management tool, absence of previously certified local mines, the strong worldwide anti-asbestos environmental campaign, and general perception of mines as serious envuonmental polluters and hazards to human safety

The AA Mines case has demonstrated that by attaining ISO 14001 certification, an organisation can improve its environmental performance and get better access to global markets The AA Mines case also indicated that by implementing ISO 14001, a positive mmd-set change can occur on the perception of process waste by employees

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Some Aspects Concerning the Stability of Waste Dumps

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ABSTRACT: The present papei aims to conti ibute to the improvement of ecological management decisional process, in the view of rehabilitate environment quality - from the point of view of environmental factor soil by establishing the necessary objectives for stability of waste dams

1 THEORETICAL CONSIDERATIONS

The mining activity perfoimed in Romania until the year 1989 was focused mainly onto reaching high production levels, fact which had led to neglect ecological issue and that had resulted in time of very serious damages for the environment

Rehabilitation of mining wastes dams ıepresents a constant concern of all specialists, who had cooperated along the years with very good results

The sliding of side slopes is part of the most complex natural processes, by the large numbei and vanety of the factors involved in bringing them abou and that is why side and slope stability has to be toieseen and assessed

Table 1 Situation of waste dumps in accordance with the souices of waste deposits affeient to mmmg actıvıtıes

Provenance of stored deposit	Storage surface (ha) Active	Pasive / In conservation	Total (ha)
From underground works	23 64	93 08	116 72
From coal processing plants	45 62	44 91	90 53
Total (ha)	69 26	137 99	207 25

As a result of the activity carried out at undei ground and piocessmg coal plants had been ıesulted a large amount of waste that were deposited in waste dumps

Piesent situation of the waste dumps as well as their location into the mining penmeter of Jiu Valley is presented in Table 1

In the view of rehabilitating die Jiu Valley environmental quality, as regard the "soil" factor, it is imposing the improvement of ecological management It will be establish the affeient objective concermng the ecological ıeconstructıon

Fiorn geological point of view, these deposits consist of the following types of rocks shale, mai ly - shales, marls, shaly - mails, marls - limestone, shmes, cmdei, etc

Deposits of waste dumps resulted from coal piocessmg plants in addition to the waste slimes resulted from the coal processing activity, includes also a lange of elements such as chemical ıeagents, lubricants, diesel, tar, etc

The settling ponds affeient to Coroesti coal piocessmg plant, with 24 8 ha total surface, occupy an important land area located in the Western Jiu light riverside, at 250m distance to the coal processing yard From technological point of view, the settling ponds have been formed by storing the residual slimes resulted from coal piocessmg process peifoimed at Coioesti coal processing plant onto a honzontal platform embanked all aiound its surface Onto the settling ponds' supporting sides, the large size waste ıesulted from coal screening and ciushing processes together with olheı ıesıdues resulted fiom the technological process of Coioesti coal processing plant, have been transpoited and stoied. In order to protect the settling ponds against the possible Western Jiu water floods, protective walls have been built

2 THE SYSTEM ANALYSIS OF SIDE STABILITY

The study stages of the instability phenomena aie presented m flow chart m Figure 1 The assessment of the mining works' stability was perfoimed by taken into consideration the stiuctural and physical characteristics of the locks and the stress - stiain state in the rock massif representing the input parameters, (Mannescu, 1988)

Besides, the deterministic and probabilistic methods based on measurements and observations, stability analysis can be undertaken by estimating the *stability factor*

A complete definition of the stability factor can be given by comparing the stress state in the sliding plane, $F_s = t/r$, where,x_f represents the value of the mobilized shearing strength and it is the value of the tangential thrust produced in the rock- mass

Numerous methods of analyzing stability can be classified according to different criteria, nevertheless they can be classified into two large categories

Methods of static equilibrium

Methods of deformation, based on the stress-strain relation,

or mixed methods (Manea, 1998)

In the second category, the determination of the Stress State in the rock- mass, this is compared and done by several techniques

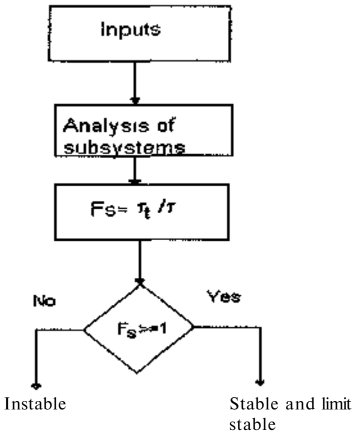

Figure 1 The flow chart of stability system

The method divides the analyses environment into small domains, on which a simple distribution of stresses and strains is considered, while the stresses are average on a finite volume in the rock mass The ' a priori" knowledge of the position of break surface, by applying the finite element method indicates the areas with stress concentration and their evolution with the load state, the areas with tensile stress and the displacements before slope break (Arad et al 2000 a)

3 RESULTS AND COMMENTS

In the paper, the determination of the Stress State was earned out using the finite element method (Salvadon and Baron, 1972)

In the case of a waste dump, which can become unstable owing to weather phenomena the analysis method of the Stress and Strain State by the finite element method had been applied For the conditions from Jm Valley coal Basin at Ileana 1 waste dump the solution of the numerical modeling was obtained The Ileana 1 waste dump lies on an area of 14 26 ha, having 21 m average height and a volume of 4 283 656 m^3

From the laboratory tests and the material characteristics it is known that the elasticity module, E= 200x $10^6 N/m^2$, Poisson coefficient u. = 0 3, inner friction coefficient q> = 34", apparent specific gravity *y* = 2 2x10^4 N/m^3, volume weight y =2 31x10^4 N/m\Arad et al, 2000 a)

The displacement on the contour of the slope and Stress tensor has been plotted in Figures 2 and 3

In Table 2, are given the values of the parameters characterizing the stress state calculated in the point at the side bottom, the side top and the critical point to right extremity of the geometric model The model of the slope waste dump is rendered in Figures 2 and 3

Table 2 The parameters of the stress state for the geometric model

Parameter (UM)	At the slope top	At the slope bottom	In the critical point
	Value		
S_x(m)*	100	0 89	0 79
5»(m)*	-0 71	0 52	100
CT_T,(10^sN/m'r	4 14	2 07	6 21
a_M,(10^vN/m')**	1 89	311	49
0_x(1O^{v}N/m')*"	2 96	0916	48
aW Nlnr)""	28	169	355
$i_{x)}$<10^vN/mT"	1 82	0 85	2 59

* Displacement

** Tresca and von Mises Stress

•"• Stress tensor

Legende
—*— Stress c

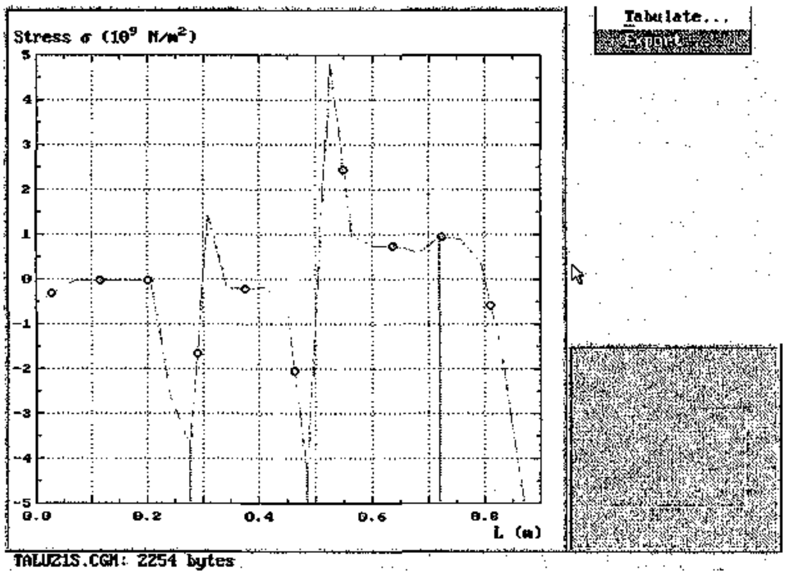

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Fig. 2. The Variation form of the stress tensor .on the side slope

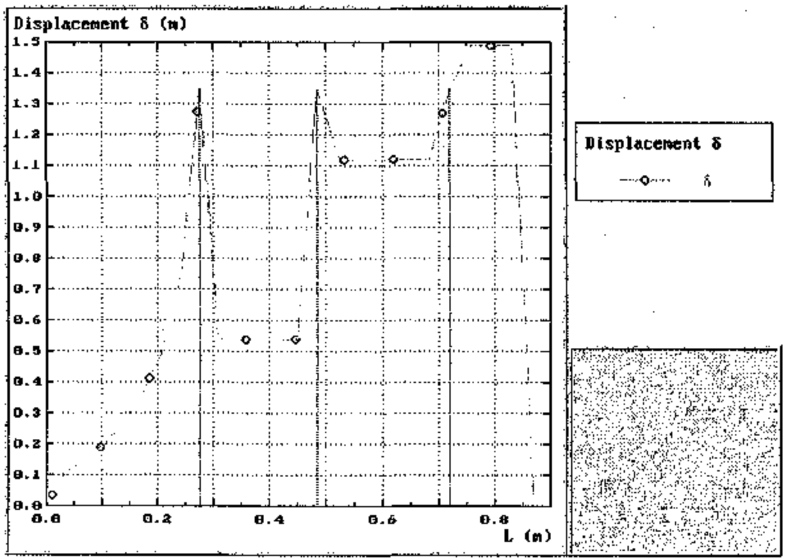

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Fig.3 The variation of the displacement of the slope contour

4 CONCLUSIONS

Corroboration of the results obtained by numerical methods, of slope modeling, and the statistical processing of the large number of instability phenomena by long term observations on them imposes making out prevision charts ot instability phenomenon

The prediction on slope stability, and in general on that of sides, is a requirement due to the negative impact ot the instability phenomenon on the environment

The numerical methods for the simulation of the Stress State in the waste dump of block were examined to assess their use in prediction sliding ot the slope (Ai ad, 2000b)

From the analysis of the results obtained we find out that the stresses occurring in the waste dump slope are higher than the corresponding mechanical resistances ($o_{ro} = 5x10^6$ N/m^2, $a_a = 1x10^6$ N/m^2, $i_{rf} = 3\ 41x10^6$ N/m^2) determined in the laboratory, therefore the slope is unstable

Regarding displacements, it is found out that these have maximum values on the vertical, which does not, however, affect waste dump stability

The accident data recorded from mine tailings dams indicate that the great majority of the sliding of these deposits occurred as function of the bad and low strength of dam foundation properties

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Parameters Affecting Mine Gas Drainage And Outburst Control Research

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ABSTRACT: Removing gases form mine environment represents the most important challenge that any mine operator is faced with. The ease with which the challenge is met and addressed depends on better understanding of the various parameters. Coal permeability and porosity is one of the key factors affecting the drainability of the coal. Coal matrix structure and coal mineralization provide a key to various issues related to effective drainage. Abnormal geological intrusions such as faults and dykes are likely to adversely affect the drainability of the coal seam. A combination of coal permeability, volumetric matrix change and petrography studies has been found to provide a new methodology in determining the ease with which a coal seam can be drained particularly with respect to geologically difficult sites. Various methodologies and techniques are described to provide the latest of research currently been pursued at the University of Wollongong, NSW, Australia, which is now providing a clear direction to predicting the drain ability of gassy coal seams.

1. INTRODUCTION

The capture and utilisation of methane gas is receiving increasing attention in recent years as mines are gearing up for high output in order to remain economically viable, particularly in export oriented countries like Australia. Methane, as the major component of natural gas, is drained from the coal seam prior to mining and the most common method of high rate of gas drainage is by borehole drainage. Figure 1 shows a typical patterns of gas drainage systems currently been implemented in various Australian Mines. A lead time around six months is generally allowed prior to the commencement of mining the predarianed coal panel.

The success of a coal drainage programme by borehole drilling is influenced by the geological conditions and also by the gas environment. Accordingly, there has been a continuous programme of research at the School of Civil, Mining and Environmental Engineering, University of Wollongong for the past two decades to provide essential research needs of the Australian coal industry. Initially the main study was related to sorption technique for determining gravimetrically the gas content of coal, and the extended later to the volumetric method. Other studies undertaken include the modelling of gas sorption in coal. The next phase of the research involved the development of a multi function outburst rig

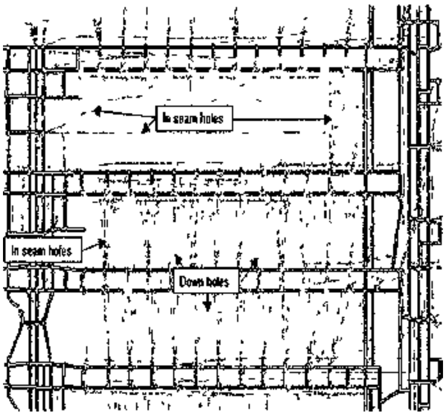

Figure 1 Typical pattern of gas drainage drilling

(MFORR) for outburst research. The MFORR was initially used to study the effect of gas environment on the strength properties of coal including:

i) The effect of gas pressure on coal tensile strength, using the well known Brazilian method of indirect tensile testing of cylindrical core samples in different gas pressure confinements,

ii) The effect of gas pressure gradient on coal load bearing capacity, and

iii) Study of the strength of coal by examining the particle size distribution of drill cuttings under different gas environments. A high precision drill of controlled speed up to 10 different levels was used to study the changes in particle size distribution with respect to increased gas type, gas pressure. The changes in coal strength properties were also compared with drilling of coal in air (Aziz Hutton, and Indraratan, 1996)

Concurrent with the above, an extensive study of various coal seams gas content was conducted using an in-house built adsorption and desorption apparatus. Research emphasis has since been shifted towards the establishment of a long-term database for coal properties including coal permeability, coal shrinkage and coal petrology. The later aspect of the study is the establishment of indices for coal drainage characterisation.

2. EQUIPMENT DESCRIPTION

2.1 **Adsorption** and **desorption** apparatus

This equipment has been the focus of outburst programme research for the past two decades. Initially it was constructed to determine indirectly, and gravimetrically the gas content of coal at different gas pressures, nowadays it is also used for coal sample preconditioning, prior to permeability, coal shrinkage and coal strength tests. The apparatus (Figure 2) consists of number cylindrical pressure vessels, known as pressure 'bombs'. Coal samples are sealed in gas bombs and pressurised to a saturation level at various predetermined pressures up to 5 MPa. The sample containers are immersed in a water bath, but are isolated from the water bath by copper sleeves to keep them dry. A thermostatically controlled water bath (with a stirrer) allows the coal samples to be kept at the desired temperatures. Further details of equipment construction, operation and gas content calculations at various pressure levels are described elsewhere (Aziz, and Ming-Lee, 1999).

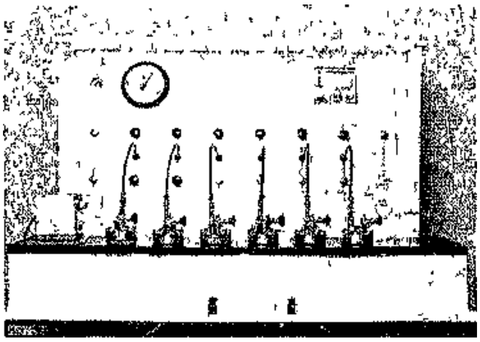

Figure 2 High pressure sorption /desorption apparatus

2.2 Coal Shrinkage test

Figure 3 is basically the pressure vessel (bomb) component of adsorption and desorption equipment used previously for indirect method of determining the gas content of coal. The only modification introduces to the bomb is the addition of pressure transducer on the lid of each bomb to monitor the bombs inlet gas pressures. Coal samples are sealed in gas bombs and pressurized to a saturation level at 3 MPa. It is then immersed in a water bam to maintain it at a constant temperature of around 25".

Before, the coal samples are placed in the bombs; four strain gauges are mounted on each sample surface to monitor axial and radial strains on coal size due to gas sorption. The mounting of the strain gauges is carried out in accordance to International Society of Rock Mechanics (ISRM) standard. A data taker 'model DT50' is used to retrieve information from the bomb which is then connected to a PC for data analysis.

2.3 Multi Function Outburst Research Rig (MFORR)

MFORR comprises a number of components, which can be utilised on a variety of research studies, initially built for the study of the evaluation of changing coal strength properties with respect to changing gas environment of the coal sample tested. At present the rig is used mainly for coal permeability studies. The integrated components

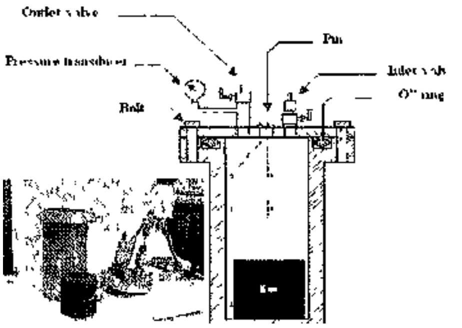

Figure 3 Coal shrinkage test vessel (Bomb) of the MFORR include

1. Main frame
2. Gas pressure chamber - also used for coal permeability studies
3. Drilling system
4. Drill support frame
5. Drill cutting collection system
6. Universal Socket for vertical load application,
7. Flow meters (see in Figure 4)
8. Data Acquistion System
9. Various components for coal strength properties tests

Figure 4 shows a general view of the MFORR. The components of the MFORR are interchangeable with respect to the type of tests undertaken. The main frame comprised a sturdy steel structure, which houses the gas chamber, a drilling frame which carried the drill, the universal thrust connector and the drill motor speed controller. The gas pressure chamber is a rectangular prism of cast iron with removable front and back viewing plates. The dimensions are 110 mm x 110 mm x 140 mm.

2.3.1 MFORR for Precision drilling and coal strength analysis

When used as a precision drill, the pressure drill rig (PDR) consists of drill frame, drill motor with drill bit, drilling thrust system and drilling cutting collection device. A multi-pulley system enabled constant thrust to be applied on the drill bit. The thrust is generated by a suspended steel cylindrical bucket filled with lead shot. The drill-cuttings are collected in a specially designed catcher, fitted with a disc of filter, and connected to a suction pump. The collected drill cuttings are subsequently weighed and analysed for particle size characterisation. A Malvern particle size analyser is used to conduct particle size analysis of drill cuttings. The particle size analyser is capable to classifying particle sizes between 1 mm and 0.5 microns (urn).

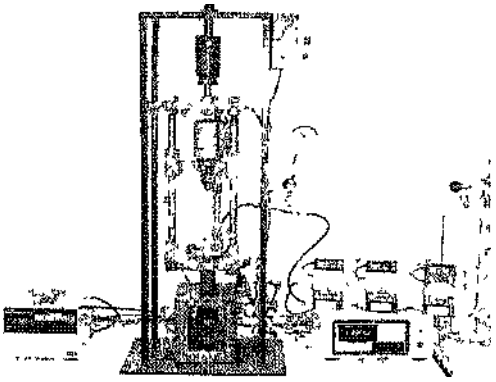

Figure 4 A general view of MFORR

2.3.2 MFORR for permeability test

When MFORR is used for coal permeability, the precision drill section and drill cutting collection system are disengaged and the gas pressure chamber is reassembled to cater for the needs of the permeability tests. Figure 5 shows the schematic diagram of the test rig (Sereshki, Aziz and Porter, 2004). The high-pressure gas chamber is connected to a set of flowmeters for monitoring gas flow rates. To conduct the test, the samples are cut into 50 mm lengths, and the ends polished. In the centre of each sample, a 6 mm hole was drilled through each sample. The sample ends are then sealed with a lock-tite seal. The core sample is then placed between loading plates of the chamber. Axial strain is then applied to the core sample via a universal torque. Changes in the sample axial and lateral load dimensions due to gas sorption are monitored by two sets of strain gauges. Parameters mat are monitored include:

a. Application of stress
b. Measurement of strain on the sample
c. Measurement of gas flow rate
d. Application of constant circumferential gas pressure
e. Application of constant suction.

Gas is charged into the sealed pressure chamber at a pressure of 3 MPa and maintained constant for a period of one week to allow the coal to be sufficiently saturated. The strain is recorded for this period. In the tests reported here little change in strain was observed over the time period. Once the sample was fully saturated, the release valve was opened and released gas passed through various flow meters of differing flow rates consisting of:

- Low flow range 0 - 100 ml / minute
- Medium flow range 0 - 2 L/ minute
- High flow rate 0 - 15 L/ minute

Information from the load cells, strain gauges and flow meters were monitored in a data logger connected to a PC.

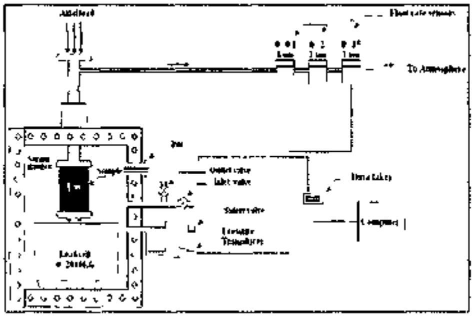

Figure 5 Schematic diagram of permeability test rig

3. RESULTS AND DISSCUSION

3.1 Gas Type And Pressure and Coal Strength Relationship

Figure 6 shows the bar charts of three different gas sorption quantities in Bulli coal seam, Sydney Basin. The gases used were CH4, CO, and CH_4 / CO, (50%) mixture. There is a clear trend of different gas sorption quantities in coal, with the higher sorption being of $C0_2$ gas.

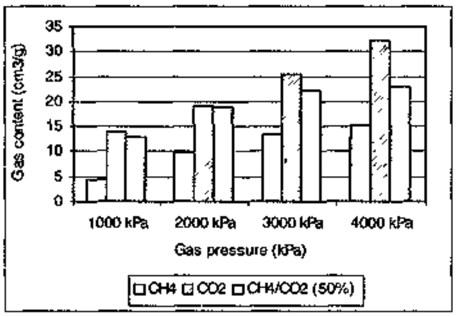

Figure 6 Sorption levels of CH4, C02, and CH4/ C02 at various pressures of Bulli coal seam

Figure 7 shows the average values of drill speed record of coal specimens tested under both in air (i.e., normal atmospheric condition) and under increased gas pressures of 1 500 and 3 000 kPa. Ten tests were made for each sample environment. The rate of drilling of coal samples m air was relatively slower than that drilled in higher confined gas pressures. The highest values were obtained m $C0_2$ confinement. The increase in gas pressure to 3000 kPa also resulted in an increase in the rate of drilling.

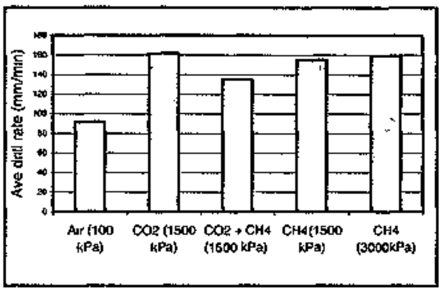

Figure 7 Drilling rates in coal under different gas types and confining pressures.

Figure 8 shows particle size distribution of drilling cuttings in various gas pressures. The graphs represent the mean line for 10 samples tested under each gas type and pressure. The particle size distribution ranged between 0.5 urn and 878.67 urn. Drilling in air produced finer particle sizes than drilling under gas pressure confinement. Additional observations made include:

- Drilling in C02 environment produced coarser particle sizes than in CH_4 and CH4 /$C0_2$ environment at 1500 kPa pressures.
- The coarse particle size were lower in CH_4/CO, and even lower in CH_4 alone environment
- Increasing CH_4 gas pressure confinement to 3000 kPa produced coarser drill cuttings. In fact the particle size distribution for CH_4 at 3000 kPa was similar to that produced from drilling in coal saturated with CO, gas at a confinement pressure of 1500 kPa. This is to be expected, as the increased gas pressure to 3000 kPa may have forced more gas into coal micropores leading to a reduction in surface energy of the coal.

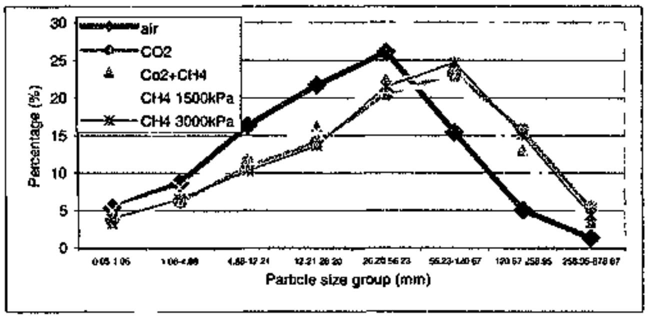

Figure 8 Particle size distribution of drill cuttings in various gas pressures

All this indicates that the presence of confining pressure has a detrimental effect on the strength of coal. It is possible that the presence of sorbed gases in coal at higher pressures may weaken the coal tensile strength by introducing micro-fractures into the coal structure. According to established facts and reported by Gray (1995), heavily fractured and soft rocks usually produce coarse drill cuttings with high rate of drill penetration.

Coal Shrinkage Test Results

Changes in the volume of coal matrix were calculated using the average of the two strains in the axial and radial directions. The shrinkage coefficient (C_m), is defined as the rate of change of coal matrix volume to the change in gas pressure and is given by (Harpalani and Chen, 1997):

$$C_m = \frac{1}{V_m}\left(\frac{dV_m}{dP}\right)$$

Where

V_m = Matrix volume (m^3)
dV_m = Change in volume (m^3)
dP = Change in applied pressure (MPa)
C_m = Shrinkage coefficient (MPa^{1})

Figure 9 shows die relationship between applied gas pressure and volumetric change in coal. The coal sample was initially charged to a maximum pressure of 3 MPa. The changes in coal volume were monitored in increments of 0.5 MPa. As can be seen, the reduction in coal volume is different for different gas medium.

A minimal change in coal volume was measured with nitrogen while a CO2 environment produced the highest volume change. Obviously, the influence of CO2 reflects a strong affinity of the gas for coal. As coal adsorbs CO2 more strongly than methane, it is thus likely the high rate of gas storage in coal is accommodated with the increase in coal volume. Clearly the change in coal volume in this case is more than five fold in CO_2 in comparison with the methane environment.

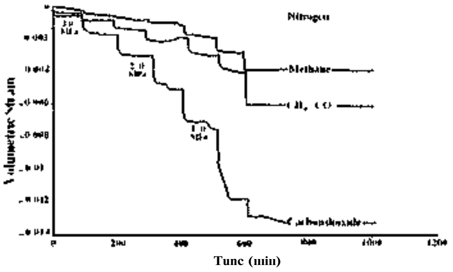

Figure 9 Volumetric strain for different gases and pressure reductions at increments of 0.5 MPa

The relative change in coal volume in mixed CO2/CH4 environment is between pure CH4 and CO2, but the mixture proportions influenced the degree of volume change.

3.3, Coal permeability test

Figures 10 and 11 are permeability graphs of coal samples tested in both methane and carbon dioxide gases under different gas pressures. The axial applied load was maintained constant at 2000 kg. The Bulli seam coal samples tested were collected from two geologically different locations in a local mine working Bulli seam in the Illawarra Coalfield of Sydney basin, NSW. Samples collected came from 800 panel (Sample #800051) and 900 panel (Sample # 900114 and #900104).

The geology of these two areas at hand specimen scale is significantly dıffeıent and can be described 800 Panel - 'normal' coal in terms of cleat spacing and orientation, orthogonal, regular spacing, normal ordered horizontal bright and dull layers, does not display visible deformation

900 Panel - 'structured' coal with bioken structure, cleats often not sub vertical, cleat spacing irregular, occasional small scale dislocation amongst bright and dull layeıs Calcıte mineralization often found towards the top ot the seam, usually oblique to bedding plane but tends towards bedding plane in lower parts of each vein

From a pıactıcal perspective, gas drainage has been exceedingly difficult m the 900-panel area when compared to the 800-panel area Management has ıesoıted to die 'grunching' method of heading development using explosives, particularly where gas content levels have been greater than the allowable gas threshold limits The coal structure has been disturbed to a point wheie the contained gas does not freely move fiom high inseam fluid pressuies to the drainage lines

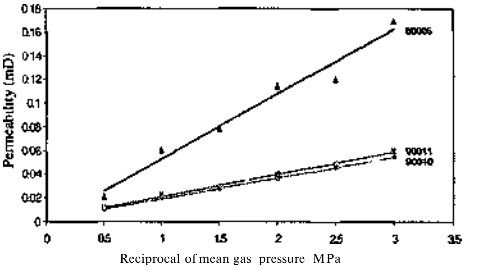

Figure 10 Coal permeability m carbon dioxide at different gas pressures and at 2000 kg axial load

The permeability of each sample was calculated using the following Darcy flow equation (lama 1995)

$$K = \frac{mQ\ln(r_0/r_i)}{\pi l(P_0^2 - P_u^2)} \qquad (2)$$

Where

K = Permeability (Daicy)

1 = Height of sample (cm)

Q = Rate of flow of gas (cc/sec ')

Po = Absolute pressure in chamber (bars)

r« = External radius of sample (cm)

r, = Internal radius of sample (cm)

P_u = Absolute pressuie in outlet (bars)

H = Viscosity of CH_4 (N s/nT)

The results showed a marked difference in the resultant permeability between the 800 and 900 panel coals The difference in permeability (m milhdarcy) between 800 panel and the 900 panel coal for each of carbon dioxide and methane is quite different. 800 panel had approximately three times greater permeability when compared to the 900 panel coals (Figures 10 and 11)

Permeability tests for both carbon dioxide and methane show that the 900 panel coals have much lower permeability's than the 800 panel coals Since permeability is a function of a number of parameteis including size, distribution and frequency of cleats, any phenomenon that reduces cleat porosity will decrease permeability Given that 900 panel coals contain much hıgheı carbonate contents than the 800 panel coals, and also have the lowest permeability, it is suggested that the reduced porosity of the 900 panel coals is due to the infilling of the cleats with carbonate The reduced permeability value explains why the 900 panel area is much harder to degas The carbonate in-filled cleats restrict the movement of gases fiom the sunoundmg coal to the gas drainage holes

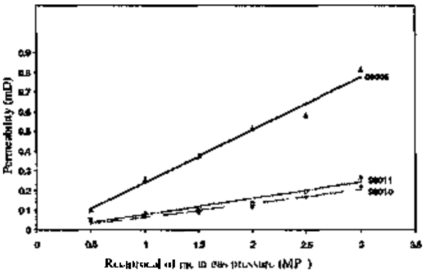

Figure 11 Coal permeability m methane at different gas pressures and at 2000 kg axial load

4 COAL PETROLOGY

The macérai analysis for the samples is given in Table 1 As can be seen there is a marked difference in the mineral mattei and caibonate content for the samples originating from 900 panel compared to panel 800 Figures 12 and 13 show the penological composition of coal from both 800 and 900 panels

Petrographically, the three samples have similar organic components They have similar vitnnite, hptimte and ineitinite contents However, the mineral contents ol the samples are quite difterent

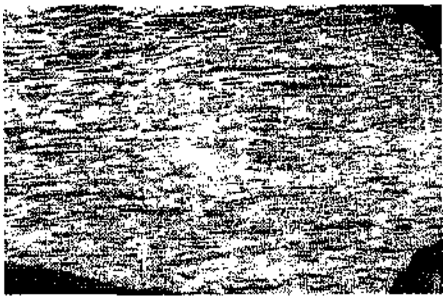

Figure 12 Sample from Panel 900 showing vıüinite with clay-filled cell lumen Clay filled lumen would reduce permeability and reduce degassing. (Field width = 0.5 mm)

Figure 13 Sample from Panel 800 showing typical composition of the Tahmoor coal characterized by inertinite layers and mixed vitrinite-inertinite layers. (Field width = 0.5 mm).

Table 1 Coal composition for different coals

Panel / Sample	VIT%	INT%	LIP%	MMO%	CAR%	CAV%	FRA%	TOTAL%
800 - S1	70.4	21.8	1.8	2.0	0	3.8	0	99.8
900-S2	68.4	19.0	1.0	2.8	2.7	5.3	**1**	100.2
900 - S2	67.8	19.8	**1.8**	6.6	1.2	2.6	0	99.8

One of the 900 panel coals contains a much higher mineral content intituling much higher carbonate (calcite). Although not in sufficient quantities to show in the point count, the second 900 panel coal also showed some carbonate. In both samples the carbonate infilled cleats and also some of the pores in inertinite macérais. If the mineral content and species is common for the coal as a whole in 900 panel, the permeabilities and degassing problems associated within the panel can be explained in terms of petrography.

The permeability tests for both carbon dioxide and methane show that the 900 panel coals have much lower permeabilities than the 800 panel coals Since permeability is a function of a number of parameters including size, distribution and frequency of cleats, any phenomenon that reduces cleat porosity will decrease permeability. Given that 900 panel coals contain much higher carbonate contents that the 800 panel coals, and also have the lowest permeability, it is suggested that the reduced porosity of the 900 panel coals is due to the infilling of the cleats with carbonate. When viewed on a mini scale, the reduced permeability also explains why the 900 panel area is much harder to degas. The carbonate infilled cleats restrict the movement of gases from the surrounding coal to the gas drainage holes.

5. CONCLUSIONS

The programme of research activities reported in this paper is a clear demonstration of our commitment in maintaining research on coal and gas s outburst as a priority research for the benefit of the coal industry. It has been demonstrated that:

1. The study of the effect of gas pressure on coal strength through the analysis of particle sizes is a valid approach,
2. Permeability and shrinkage studies can serve as an effective approach in understanding the drainage characteristics of coal seam with intrusions and other geological disturbances. The effectiveness of these methods can be better enhanced through assessment of coal composition and mineralization.
3. The status of current research programme perused at the University of Wollongong, is a continuation of the research work dating back to more than two decades. We are looking ahead to better utilise the latest know-how and technologies for the establishment of a predictive indices for safe mining and improved production and productivity.

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What is Expected from Safety Engineers, Trainee in the University of Mining&Geology "st. Ivan Rilski", Sofia

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ABSTRACT; Modem trends in engineering expect a great deal towards machine and human safety and towards thus formed working environment. These trends equalize safety standards priorities with quality and environment management. Standards implementation and their proper application require special knowledge in the field of Safety Engineering. This paper presents main ideas and their current realization in 2001 started Master program on Safety Engineering at the University of Mining&Geology, Sofia as well as its compliance with qualification requirement to graduated specialists.

i BACKGROUND

The most featuring process in safety during the last century is its expansion. Engineers are responsible for the safety of constructive, design, technical, technological and management solutions in all phases of life cycle of me products. However, development of science and techniques demand implementation of innovative solutions in extremely dynamic way in order to meet competitiveness of products ensuring better quality of life. In the same time sustainable development of industrial society requires increased indoor and outdoor safety. Following the above stated provisions, international standards (ISO9000, ISO 14000 and ISO 18000) have already acknowledged work environment safety management (ISO 18000), as equal in priority as quality (ISO9000) and environment (ISO 14000) management. As a result of such prioritization, social necessity of professionals with deeper specialization arose in order to meet its creative realization. In Bulgaria such specialists can be safety engineers, upgrading their BSc background in engineering fields at Master level.

In order to meet social needs for safety specialists, the University of Mining&Geology "St. Ivan Rilski" started in 2001 new Masters programme in Engineering Safety. This paper deals with main directions and subject-matter which can help to increase creativity and knowledge of future safety engineers, based on experience of started few years ago Masters program in Bulgaria.

2 WHY STUDY AT MASTEES LEVEL AT MINE FACULTY

Our analysis for engineering study in Bulgaria as well in other countries, utilizing three-level education system (BSc, MSc and PhD) show that engineering study at BSc level ensure good background, which can serve as a basis for deepening and broadening of knowledge in the field of safety. Problems, which one safety engineer can solve are of great responsibility that is why his qualification should be at higher than BSc level. This does mean that at this stage BSc study in safety is not necessary.

Department of Mine ventilation and labor safety, part of Mine-technological faculty of the University of Mining&Geology, Sofia, has more than 40 years experience in safety education of mine students and professionals. This tradition in safety education in one industry with high level of risks, oriented department staff in development and implementation of education in engineering safety at Master level. Thus in this education and science field have highly professional lecturers, ready for the new specialty. Mining is one of the most risky industries. This predefines the orientation of educational process in the University of Mining&Geology towards very high standards in the teaching process of health and safety at work. Such background makes possible extension of educational process to other industrial activities and creation of Master program in Safety Engineering at the Department of Mine Ventilation and Labor Safety. This department provides postgraduate education in School of Safety in Mining and Geological Survey 25 years already with practicing engineers

3 FUNDAMENTAL OF THE STUDY - ADMISSION REQUIREMENTS AND MAIN SUBJECTS

Specialized knowledge in physical, chemical and social sciences is mandatory for practicing safety specialists They should perform not only measurements and analysis as used to be till now, but also to synthesize new solutions for effective risk management That is why admission procedure claims fundamental knowledge in Maths, Statistics, Physics, Chemistry, basic engineering, and computer skills from candidates

Table 1 presents the Program syllabus, combined in three semesters Eight compulsory and three elective courses (chosen from six) are included into program Two types of study are foreseened - full-time and part-time. Some ideas for development of distance learning exist Study duration is three semesters with defense of Master thesis at the end Total number of credits is 129, including 60 in auditorium classes students occupation and 69 in self-work on projects and tasks

Mandatory courses numbered 1, 2, 3, 4, 7, 8, 9 and 10 provide special knowledge to students, and elective courses numbered 4 and 5 supplement the special knowledge

Mandatory courses "Computer methods in safety" and "Language and information training" augment the remaining courses of the syllabus and provide knowledge and skills that are mandatary for the trainees These were developed on a module basis with scheduled interaction both between individual modules and other courses

Module A of "Computer methods " gives additional (as compared to bachelor's degree level) knowledge for working with electronic tables and databases Practical courses comprise mostly individual work and assignments on other subjects - for instance, assignment on "Industrial ventilation" or analysis and processing of measurements in "Industrial hygiene " Module B of "Computer methods " further improves students' knowledge in Safety statistics focusing on processing of statistical and other data, criteria evaluations and verification of hypotheses " Practice on above mentioned courses include solving of problems for analytical or graphic processing of information obtained during studying of other subjects of the current semester

Language and information training comprises three modules, as follows

- Technical translation from foreign language - Module A
- Information retrieval systems - Module B
- Document and report writing and presentation - Module C

Information search, translation, documents prepared and presented, all are generated from other courses of the semester of the master's degree study as a whole

Table 1 Syllabus of the study

N	Subject	Credits
	First semester	
1	Industrial safety (I part)	6,8
2	Industrial Ventilation	5,7
3	Industrial hygiene and professional diseases	5,5
4	Computer methods in safety - Module A (Databa&e management)	2,4
5	Language and information studies - Module A (Translation)	2,2
6	Elective course (1-st, 2-nd or 3-rd elective)	2,2
	Second semester	
7	Safety psychology and ergonomics	6,8
8	Industrial safety (II part)	3,4
9	Fire safety and rescue	7,4
10	Management of safety and industrial risks	5,7
4	Computer methods in safety - Module B (Applied statistics)	2,4
5	Language and information studies-Module B	2,4
11	Elective course (among 4-th or 5-th elective)	3,4
	Third semester - work on MsC thesis	
5	Language and information studies - Module C	2,4
12	Elective course (among 3-rd, 4-th or 6-th elective)	6,8
	Pre-thesis practice	3,0
	Lectures and seminars on Masters' thesis	15
	Consultations on Masters' thesis	
	Defense of Masters' thesis	
	Elective courses	
E1	Microcosiology	2,2
E2	Mine safety	2,2
E3	Applied illumination	2,2
E4	Drilling, exploration, transportation, storage, and usage of oil and gas	5,7
E5	Geotechnical safety	6,8
E6	Ventilation and air conditioning systems' control	6,8

The elective course "Drilling, Exploration, Transportation, Storage, and Usage of Oil and Gas" enhances students' knowledge about widely applied technology in the country and with high degree of risk

The elective course "Microsociology" provides essential knowledge to be used as basis for personnel management training - a problem which every engineer faces regardless of their chosen field of carrier.

The elective course "Applied Lighting Equipment" supplements the knowledge on labor hygiene and ergonomics and provides essential knowledge on accident reporting.

Elective course "Mine Safety" choose students, who wish to obtain more qualification in this field as well as students with B.Sc. from other than Mining University.

Diploma thesis and pre-diploma internship are related to specific sites whereof risk assessment, safety plans and other documents and analyses of use for the company are developed.

4 WHY WE ARE COMPARED WITH OTHER MASTERS PROGRAM IN THIS FIELD

There is not similar education in Eastern European countries in the field of Safety Engineering. University of Nis at Serbia has safety education based on BsC in safety. It is more targeted towards safety work conditions rather than risk management and minimization. Table 2 presents quantitative analysis of similar Masters programs in Indiana University of Pennsylvania (USA), University of New South Wales (Australia) and University of Nis (Serbia). No similar programs have been found in EU.

Main study parameters have been compared - study duration, credits, main courses and study direction. This comparison shows the followings:

- Stuc*y duration is from 1 to 2 academic years for full time study and 1,5 - 2,5 years for part time;
- Number of courses vary from 11 to 15, 8 to 10 of which are compulsory, électives are between 2 and 4, projects included thesis are from 1 to 3;
- Masters studies in Australian and American universities have additional 2-3 specialties in the field of Safety. This can be explained with countries scale and need for more narrow oriented specialists because of various aspects of safety, due to its integration with other activities;
- Courses in MSc. Safety Engineering at University of Mining&Geology, Sofia are generalized, but cover the content of similar courses in other masters programs;
- Some of analyzed Master programs are based on BSc. level in Safety, which predefines the narrowed specialty;
- Departments, started safety education are further expanded to safety science schools; safety faculties; health and safety management institutes. This gives confidence to the staff of department of Mine Ventilation and Labor Safety that the work done till now is in right direction and with good perspectives.

The logics of comparison with similar programs in the filed of safety show that Safety Engineering masters study at the University of Mining&Geology is well balanced to Bulgarian scales and with practice requirements.

5. POSSIBLE STUDENTS REALIZATION

Safety Engineers oversee the manufacturing production process to ensure that every measure is taken to protect workers in the manufacturing environment. They apply principles of science and mathematics to come up with solutions to manufacturing needs and environmental effects. Engineers analyze the impact of products they develop and the systems they design on the environment and people using diem. Engineering knowledge is applied to improving the quality of health care, the safety of food products, and the efficient operation of financial systems.

6. CONCLUSION

Many Safety Engineers should be involved in products testing and in industrial and environment media control. These new engineers should also increase safety training at higher level, utilizing better understanding of behavior, motivation and communication between people and their effective management. In this way they will fulfill the mission of reaching higher standards in culture of safety, which for many countries is the best solution with greatest potential for continuous increase in safety.

Safety engineers will prepare and implement new, more liberal regulation for health and safety at work, which principals require new safety professionals. Entering into creative part of safety, which means that professionals should go beyond official normative requirement, is the great challenge for safety engineers. This mission consist of search and implementation of new technologies, design, constructive and behavioral solutions leading to risks avoidance. Expectations for such creative behavior of safety engineers are crucial in industries with high level of risk. Only in this way they can change the attitude in society that the price for better life quality in industrial era should be paid only by people, occupying health and safety risky professions

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Table 2 Comparison of masters program in the field of Safety-

Name of Masters study	Safety Science	Occupational Health and Safety	Science and Technology in Industrial Safety	Safety Science	Labor Safety	Safety Engineering
1 University	University of New South Wales, Australia [2]			Indiana University of Perin sylvama [3]	University of Nis [4]	University of Mining&Geology St Ivan Rıslkı", Sofia [1]
2 Study duration	2 years full-time 2 5 year part time	1,5 years full-time 2 years part time	1 years full-time 2 years part time	1,5 years full-time 2 years part time	2 years full time	1,5 years full-time 2 years part time
3 Number of subjects inci	13	17		8	5	11
- compulsory	4	14	12 credits	4	2 3 special	8
- elective	9	3	48 credits	4		3
- projects	42 credits	2	15 credits	3	2	-
- projects (thesis)	1	1	1	1	1	1
4 Credits	96	72	75	36		93
5 Price	$11,760/year for Australians and $18 000/year for foreigners					300 levs/ semester for BG citizens
6 Specialties	Safety Science	Occupational Health and Safety	Science and Technology in Industrial Safety	Safety Management Technical safety Disaster Response	Labor Safety Fire Safety	Safety Engineering
Structure	School of Safety Science			Safety science department Faculty of Health and Human Services	Faculty of Labor Safety	Department of Mine Ventilation and labor Safety

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