U.S. BUREAU OF MINES PERSPECTIVE ON THE MINING INDUSTRY AND NEAR-TERM RESEARCH RESULTS

T S Ary

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INTRODUCTION

The mining industry is poised to meet the Nation's needs in energy as well as the many other commodities the industry produces, but in all of these cases the consumer takes these products for granted. I will not dwell here on the need for increased effort to educate the public on the importance that the minerals industry plays in the vitality of this country as well as the economic stability of our economy. We must all continue to do our part relative to the education of the public, as well as policy makers in this important matter.

As we look forward, there are several areas that are important relative to the health and stability of the industry. Let me share with you my thoughts on each of these areas:

FINANCIAL STATUS

Industry has been affected adversely by the recessionary state of the economy during the past year. Generally inventories have increased and sales and profits have fallen. Even the most vigorous portion of the mining industry during the past few years - gold - has seen periods of falling profits during 1991-92 because of increased costs and stagnant prices.

While the coal industry will probably continue to experience slight growth of output in the coming year, the non-fuel sector of the industry is likely to see a stagnant situation even if the predicted economic up turn does occur.

REGULATIONS

The regulation of mining and mineral processing waste continues to be an issue of debate and focus. As you are aware, in 1991 the Environmental Protection Agency (EPA) issued a final determination on the regulation of 20 mineral processing wastes that had been exempt from the Resource Conservation and Recovery Act (RCRA) by section 3001(B)(3), the so-called Bevill Amendment. While the regulatory activities have had a substantial impact on the industry, this type of increased regulatory scrutiny is likely to continue and intensify.

Of direct importance to the coal industry, are the amendments to the 1990 Clean Air

Act which require electric utilities to reduce their sulfur dioxide emission by 1/2 by the year 2000, at which point the emissions will be capped at 8.9 million short tons. As you are well aware, the debates and decisions continue on the use of scrubbers versus lower sulfur coals to meet these requirements.

At this time, other important regulatory issues deal with toxic substances, revision to respirable dust sampling procedures, and the issues pertaining to "no net loss" of wetlands.

The regulatory issues will continue to be a principal concern (in cost) to the industry with the most pressure coming from the environmental sector.

EMPLOYMENT

In general, the industry continues to see a decrease in employment. The gains recently realized in productivity are a result of using more labor saving equipment and in part by the continued "trimming" of support staff. I generally feel that the industry has "reached the bottom" in terms of the number of employees required to produce current output. Only through reduced regulatory burden, or improved procedures and methods (new technology) will industry continue to improve output per man shift.

INTERNATIONAL TRADE

While the export of fuel and non-fuel minerals continues to be a "target of opportunity" in terms of expanded markets as well as benefiting the U.S. balance of payments, the U.S. minerals trade has been relatively stable during the past few years. In a world economy where U.S. labor rates are higher than most other countries, and where U.S. environmental and health and safety regulations are more demanding than most other countries, for the U.S. minerals industry to be competitive requires improved production and processing methods.

TECHNOLOGY IS AN IMPORTANT PART OF THE SOLUTION

It is only from a firm technological base that progress can made in the industry. Whether it be for the assessment of the impact and benefit of proposed regulatory action, or to devise means to reduce health and safety exposure, or increase productivity, a firm technology base is necessary to ensure the ability of regulatory agencies, as well as the industry, to respond in a responsible manner.

The Bureau's Information and Analysis Directorate as well as the Research Directorate are addressing many issues relative to this topic. It is not possible today to provide an all inclusive overview of activities relative to these important issues. However, in the time available, let me share with you some examples of work ongoing or nearing completion that relates to the principal theme of this conference, namely health and safety. The examples follow:

Respirable Dust

Translucent Partition for Longwall Face Dust Control. Controlling worker dust exposure on longwall systems is difficult because the working face area serves as an immediate return during half of the mining cycle and the amount of dust is directly related to production. Since improvements in longwall mining technology have significantly boosted production levels, supplemental dust controls are needed to handle present and future production levels. One concept to reduce longwall worker's dust exposure is to maintain two splits of air at the face; a clean intake split in the worker's walkway, and a return (dusty) split over the face conveyor. Solid curtains have been shown to be almost 100 percent effective in a full scale laboratory mock-up of a longwall. However, operator visibility of the shearing machine was a particular impediment to this air splitting technique.

The Bureau has recently investigated a way to overcome the visibility handicap of face partitions by utilizing a permeable polyester mesh. The mesh material was anticipated to provide adequate air splitting capabilities as long as the pressure differential between the face and worker walkway was minimal. Initial testing of this concept at the Bureau's Lake Lynn Facility showed that notable reductions could be achieved with a 1/8 and 1/16-inch mesh opening size. Dust reductions at 100 ft and 200 ft downstream of source were 58 and 36 pct, respectively for the 1/8-inch mesh and 79 and 55 pct, respectively for the 1/16-inch mesh.

Longwall application of the 1/8-inch mesh attached to the shields showed a 52 and 43 pct dust reduction 100 ft and 200 ft, respectively, inby the shearer when the mesh was kept parallel to the face airflow during the head-to-tail cut pass. The partition subsystem was designed to be shield mounted by brackets attached to the shield canopy. The mesh material for underground testing was specially manufactured in a flame retardant polyester material. Flexibility between shields was accomplished with elastic surgical tubing connected to the brackets and temporary face side lighting was provided through portable DC lighting mounted on the shearing machine. However, this system showed no dust reduction effect during the tail-to-head pass. The shield movement during this pass caused an irregular stepping effect with the mesh into the airflow, nullifying the air splitting ability of the mesh. The mesh material was durable and held up well, but it was determined that system modifications are needed to reduce mesh irregularities and provide additional face side lighting. A second study is planned to address these system modifications.

Dust Instrumentation. The Bureau is investigating technologies to improve respirable dust monitoring and to identify systems that could provide continuous dust monitoring. MSHA has indicated a need for a respirable mass concentration monitor that can provide on an hourly basis dust levels and be capable of operating maintenance-free for at least 30 days.

The Bureau is pursuing sensor technologies that will meet advanced respirable dust measurement requirements, both in-house and via contract research. The Bureau intends to award a contract before September 30, 1992 to study new sensing techniques. Meanwhile, the Bureau is studying more conventional dust monitoring technologies. These technologies include light scattering, light absorption, beta attenuation, and resonant oscillating frequency techniques like the TEOM dust monitor. The Bureau intends to determine the applicability of these techniques to continuous monitoring of respirable coal mine dust.

Disposable Filter to Reduce Diesel Exhaust Particulate Emissions. The Bureau has developed a low-cost, disposable diesel exhaust filter system. The System is intended for use on Part 36 permissible equipment or other machines equipped with water scrubbers. The filter system is located downstream of the water scrubber to take advantage of the cool exhaust produced by the water scrubber. Demonstration systems were tested on Jeffrey 4110 and 4114 Ramcars in Alabama and Utah.

The filter system consists of a water trap, an optional over-pressure relief valve, a filter canister, and a filter element. Under normal operations, exhaust from a vehicle that is equipped with a water scrubber is laden with water, especially immediately upon start up. The water trap is designed to remove most of the water droplets from the exhaust before it enters the filter, thus improving filtration. After the exhaust exits the water trap, it passes through the filter. The Donaldson Company manufactures the filter element, which is quite similar to intake air filters used on over-the-road diesel engines. It is cone-shaped, 24 inches long, has 270, 2-inch pleats, and is constructed of a paper-like material.

Two week-long field studies were conducted to evaluate the performance of the disposable filter system. The field study evaluated the effects of the filter system on air quality in one high-altitude and one low-altitude underground coal mine that used diesel haulage on a continuous miner section. All production diesel machines in the mining sections were equipped with the exhaust control system. In-mine tests compared ambient soot levels with and without the filters installed. The reduction of soot was measured by using size-selective aerosol sampling. Samples were collected during normal production shifts in the ventilation intake, haulageway, on the machine operators, and in the return air. Analyses of measurements indicate that diesel-generated aerosol was reduced, on average, by 95 pct in the high- altitude mine, and by 72 pct in the low-altitude mine. The tested filters had a useful service life ranging from 12 to 32 hours and cost about $40 each. Filter life may be extended by practicing proper engine maintenance, eliminating unnecessary engine idling, and ensuring proper functioning of the water scrubber.

Haulage Truck Safety

The operation of haulage trucks in surface coal mines continues to be a major source of fatalities and injuries. As part of its continuing effort to reduce hazards associated with haulage truck operation, the Bureau of Mines has completed a project oriented towards the safe operation of haulage trucks on stockpiles and wastedumps. The results of this work include the development of computer code (INSLOPE3) based on the kinematic method of limit analysis which determines an admissible truck weight for varying distances from a slope edge. The program considers the material strength parameters, slope geometry, and inertial forces induced by vehicle braking. The program can be used to assist in the determination of safe operating distances for a haulage truck from a slope edge and the development of safe operating procedures. An executable version of the program and an accompanying users' manual are available. In cooperation with the U.S. Mine Safety and Health Administration (MSHA) the Bureau has also developed a Stockpiling Safety Manual. This manual discusses the hazards associated with stockpiles and reviews the procedures that can be used to minimize the occurrence of accidents, providing clear, concise, and practical information for the mine operator. The safety manual can be obtained from the National Mine Health and Safety Academy, Beckley, WV, by requesting Safety Manual No. 30.

Ground Control

One of the greatest expenses in mining is the support of ground. It is also an area where accidents (25 pct) and fatalities (40 pct) are a significant percentage of the total experienced in the underground mining industry. Several Bureau thrusts to address these issues are highlighted below:

Gate Roads. Longwall mining is undeniably the major U.S. underground coal producing system to emerge in the past decade. At the present rate of productivity growth, longwalling is expected to account for nearly 50 pct of total underground production by the year 2000. Yet, surprisingly, the dramatic rate of growth witnessed over the past decade has not resulted from an expanding longwall industry; total longwalls operating today (93 est.) are only four more than the 89 in use in 1980. Rather, it has largely been the rapid advances in face support, cutting and haulage technologies that have enabled today's longwalls to mine unit-shift tonnages nearly twice that of just five years ago. The semi-automated, high-capacity longwall systems recently brought on-line have also facilitated expanding face widths (now up to 1,000 ft), panel lengths (over 13,000 ft), and mineable seam heights (approaching 18 ft). Such rapid advancements, however, are not without their shortcomings; now, more than ever, insuring mine safety demands a careful coordination between ground control and operations

planning.

Among the various engineered components of the longwall operation, perhaps no one is more critical to mining success than the gateroad system. The gate entries provide for the ingress and egress of workers, materials, and ventilation, as well as the removal of coal from the face, and must be designed with such caution as to assure their accessibility throughout the mining sequence. Failure to provide this required access may often interrupt, or even permanently suspend longwalling. Yet, purposely over-designing the gate system to ensure adequate performance is becoming increasingly difficult to do; largely limited by operational considerations—some regulatory in nature, others strictly economical. As a result, finding a gate design that assures entry stability, meets established operational safety standards and optimizes economy is a most complicated task for today's longwall planner, and one with ever-diminishing margins for error.

The Bureau currently has research underway addressing two primary gate design approaches; yielding-pillar systems and non-yielding, or abutment-pillar systems. A strong experience base in abutment pillar design, accumulated over years of room-and-pillar mining, and most recently longwall applications, has led to the Bureau-developed "Analysis of Longwall Pillar Systems," or ALPS, method for sizing abutment pillars in gateroad applications. This approach has been shown to provide realistic assessments of gate system performance based on the post-analysis of nearly a hundred case histories, and should provide consistently acceptable levels of design confidence with the future incorporation of gate geology and support system considerations. The empirical approach this design method is based upon is widely accepted: recently supported by the multi-nation attendance at the Bureau-hosted Pillar Design Workshop, held this June in conjunction with the 33rd U.S. Symposium on Rock Mechanics, in Santa Fe, NM.

Yielding-pillar systems offer a more challenging research problem, primarily due to the limited use this gate design has seen in U.S. mines. Of the experience gained to date, very little has been quantitatively supported through documented field measurements or photographic records. Despite this dearth of performance data, considerable evidence exists to demonstrate yielding systems' successful application in mitigating sudden coal bump events, as well as interburden instabilities associated with close-proximity, multi-seam mining. The Bureau is presently approaching the problem of formulating a design criterion for these systems, based on tailgate roof stability. Deficiencies in the available experience-base are being overcome by cooperatively studying similar gateroad systems in foreign mining operations, through the use of numerical modeling simulations, and by comprehensive field evaluation at each of the U.S. operations currently using this type of gate design.

The end goal of a universal gate system design methodology for all longwall applications is within reach, and is requisite to maintaining our current rate of growth in productivity without sacrificing miner safety.

Also in the area of longwall mining systems, the Bureau is conducting research to improve the selection and application of longwall shields, and to date the performance characteristics of different shield designs have been determined. For example, the primary difference between a two-leg shield and a four-leg shield is the ability of the two-leg shield to apply an active horizontal force that tends to maintain the immediate roof in front of the shield in a state of compression. Most strata control problems in state-of-the-art longwall operations are related to roof spalling in front of the shields and the advantages of the two-leg shield are being utilized to help control friable roof geologies that are most prone to this behavior. The Bureau is also conducting underground investigations of shield and strata interaction to determine how shield capacities can be

utilized most effectively. The utilization of shield capacity is largely dependent upon the active force that the shield is set against the roof and the stiffness of the support structure. The Bureau has been instrumental in determining the stiffness of shield supports and the influence of stiffness on shield performance and strata interaction. An initial study of the effect of setting force on shield and strata interaction indicates that setting force is not the most dominant factor in subsequent shield loading, suggesting setting pressures can be lowered in some conditions to minimize overall support loading which will enhance the life of the shield and avoid unnecessary overstressing of the strata that may degrade roof stability. However, further research is needed before an optimum setting force criteria can be developed.

Many longwall operators spend upwards to a million dollars per year in wood crib construction for support of their gateroads. The Bureau has developed a model based on full scale testing of crib supports that will allow the mine operator to select the optimum crib configuration and deployment strategy.

Instrumentation. The Ground Control Management System (GCMS) developed by the Bureau allows Bureau researchers and management personnel at the mine site to remotely monitor geostructural data and evaluate ground stability during the high-speed extraction of longwall panels. The GCMS offers a solution to the problem of coping with rapidly changing ground conditions arising from today's high-speed extraction of coal from mechanized longwall panels. The GCMS combines existing mine monitoring and sensor technology specifically for ground control management. Through the application of intelligent computer analysis techniques, the GCMS can recognize the development of high-stress zones and warn of impending ground hazards ahead of mining. Thus the mine operator has available real-time geotechnical information at the push of a button.

The Bureau, in cooperation with the mining industry has installed and is operating the GCMS in an underground western U.S. coal mine. A comprehensive instrumentation program using a fully automated, mine monitoring system and the remote processing techniques of the GCMS network was implemented to evaluate rock mass behavior during mining of three longwall panels. The field data are transmitted over a dedicated telephone to the Bureau field office 150 miles from the mine.

In-mine test results have shown that the GCMS data collection and processing capabilities can become an effective planning tool for the mine engineer to anticipate and control ground hazards. The real-time geotechnical data have indicated the development of high-stress zones along the face and impending gateroad hazards in advance of mining. The computerized analyses of historical rock mechanics data have significantly improved the understanding of the dynamic roof caving characteristics and associated roof falls, floor heave, and bumps.

This information is being used to optimize the design of gateroads and panel layouts, plan and implement appropriate ground control measures, and assess the need for supplemental supports or alternative control measures. The automated capabilities of the GCMS enable mine personnel to better monitor and control ground conditions, improving both safety and efficiency.

Localized information on the condition of mine roof prior to the installation of roof support would significantly enhance the resultant support system. To accomplish this objective, roof rock strata must be identifiable prior to or during drilling.

This is currently possible with the Bureau's smart drill through monitoring the penetration rate and specific energy of drilling. In the future, an expert drill would do the sensing remotely in a quantitative manner, and use artificial intelligence (AI) to

do what an operator and geologist now do qualitatively. Then real time decisions can be made concerning the best hole depth and anchorage system for the specific area.

Researchers have instrumented a roof bolter drill called a "smart drill" to monitor torque, thrust, rotation rate, penetration rate, and position of the drill bit in the roof. Hundreds of holes were drilled while drilling parameter data were taken at the Cottonwood Mine in Utah. Core was taken in association with the drilling to precisely identify the strata being drilled. Neural networks and pattern recognition systems are being used to analyze the drill parameter and vibration data in an attempt to identify the type of roof rock being drilled in real-time. Specific energy of drilling is currently being related to the roof strata. When a successful identification system is found, a roof-bolt of sufficient length could be drilled for proper roof support.

Disaster Prevention and Control

While disasters are not a part of normal mine operations, disaster prevention must be. The economic impact of coal mine disasters in the past few years is still apparent, both to the operating companies as well as the communities. The safety of the miners and of recovery teams is paramount in these considerations. Several noteworthy topics in this area are addressed below.

Frictional Ignition. The Bureau has conducted a workshop to bring together mine operators, manufacturers, and Government officials with the intent to catalyze the commercial development of wet-head miner technology for the prevention of frictional ignitions of methane at the face. The one-day meeting which was held in Pittsburgh focused on general discussions of the state-of-art in low incendive bits and back mounted water sprays. The high point of the meeting was the open discussion by operators and manufacturers of their field experiences with various bit types and back mounted spray systems for longwall and continuous miners. The results of the meeting has identified industry problems and needs, manufacturer's barriers, and Bureau research needs.

Belt Entry Fires. About 30 pct of underground coal mine fires occur in conveyor belt entries. To address this problem, the Bureau developed a new flammability test for fire-resistant conveyor belting. This laboratory-scale test is conducted in a 5½-ft-long ventilated chamber with belt samples 5-ft-long by 9-in-wide. The ignition source is a gas jet burner. The pass/fail results for the new laboratory-scale flammability test were in very good agreement with those obtained for the same belts in a large-scale fire gallery test. MSHA intends to replace the current Federal small-scale conveyor belt flammability test with the Bureau's new fire test for belting. This action is in the proposed rule stage. MSHA has instituted an interim program whereby belt manufacturers can have their products evaluated by the new test procedure free of charge at MSHA's Approval and Certification Center. Several belt manufacturers have also constructed the test apparatus at their plants.

The Bureau recently completed a large-scale study on the detection of fires in conveyor belt entries (RI 9380). Small coal fires were used to ignite conveyor belting at air velocities ranging from 150 to 1200 FPM. During the tests, temperature, CO, and smoke levels were measured to determine detection times as the fire intensity progressed through the stages of smoldering coal, flaming coal, and burning belt. Conditions of air velocity and sensor levels that are required for early detection of conveyor belt entry fires were defined and two nomographs prepared for CO and smoke sensors which provide guidelines for alarm levels and spacings as a function of belt entry cross-sectional area and air velocity.

At the request of the UMWA, the Bureau is currently conducting large-scale tests to examine the effect of ventilation on the detection, growth, and propagation of fires

involving conveyor belting, coal and wood.

MFIRE Mine Ventilation and Fire Computer Simulation Model. Modern mine ventilation systems are extremely complex, comprising hundreds, or even thousands of individual airways, one or more fans, and a multitude of ventilation control devices and structures. Despite the complexity, a precise qualitative and quantitative understanding of a mine's ventilation is essential to providing a safe and healthy working environment for miners during normal operations, for mine emergency planning, and for real-time control of ventilation during a mine emergency.

The thorough understanding, analysis, and control of dynamic, complex, and ever changing ventilation systems are impossible without powerful computer programs for mine ventilation network analysis. But even these programs are of little value if the ventilation system is subject to a fire or other transient event. The heat produced by a fire can profoundly alter airflows, causing low flows, reversals, and recirculation in otherwise safe and stable systems. Fires also produce life-threatening conditions such as visibility-impairing smoke, toxic fire gases, high temperatures, and elevated methane concentrations due to low air lows.

To assist mine personnel in analyzing ventilation systems subjected to mine fires, the Bureau has developed the MFIRE mine ventilation and fire simulator. MFIRE can be used for routine ventilation system planning under normal conditions, or for analysis of ventilation system changes due to a fire or other disturbance.

The program is unique in its treatment of transient events. The response of a ventilation system to a disturbance, such as a fire, can be tracked over time at user-specified intervals from the initiation of the event until new steady-state conditions are reached. Users specify fire size and characteristics in terms of heat output, oxygen consumption, and/or fume production. Output at each time interval provides an updated pressure/quantity description of the mine, pressure drop in airways, changes in flow from the previous time period, and fume and methane concentrations. Reversals and recirculation paths are also identified.

The program is now available, and approximately 300 copies have been distributed in response to requests from all major world-wide mining countries. User documentation and training aids are also available, and hands-on training workshops are provided periodically by the Bureau. Research is continuing to expand the capabilities of MFIRE, and users are provided with upgraded versions of the program when they become available.

Ultra-Low Frequency Electromagnetic Emergency Warning System. Recent quantitative studies have confirmed the generally-accepted belief that rapid and reliable warning of a mine fire is essential to minimize casualties. Rapid and reliable warning involves two steps: the fire must be detected, and all miners must receive a fire alarm signal. Early fire detection has been the subject of significant research efforts within the Bureau of Mines and elsewhere. However until recently, the second step in the process, receipt of the fire-alarm signal by all workers, represented a serious gap in mine fire protection technology.

Using existing technology, the fire-warning signal is subject to long delays and uncertainty. For example, precious time can be lost while messengers travel to the various workplaces to spread the warning alarm, and some workers might be missed altogether. Telephone lines could be damaged by the fire, or calls may go unanswered if miners are not near phones. Even UHF- and MF-radio systems become ineffective if transmitting antennas are damaged, or if there are opaque obstructions between transmitters and receivers.

A new Bureau of Mines' warning system

offers great promise for eliminating the deficiencies of existing warning technologies. The system comprises two elements: an ultralow frequency transmitter and personal microreceivers. The signal travels through the earth to compact microreceivers, which can be built into cap lamp batteries or installed on mobile vehicles. The warning signal is received instantaneously by all underground workers, regardless of their location or work activity.

In tests of prototype equipment at operating mines, through the earth transmission distances of over 1,600 m have been achieved. Two commercial manufacturers are currently marketing systems based on this technology. In addition to enabling emergency warning, these systems permit users to transmit a 32-character message from a personal computer on the surface to receivers featuring specialized liquid crystal displays built into the cap lamp battery. Users can send a message to an individual miner, groups of miners, or to the entire underground work force. These systems are useful for transmitting both emergency warnings and routine production communication messages.

When a emergency does occur that requires the use of Self Contained Self Rescuers and the need for miners to escape, the Bureau evaluates the miners proficiency as it relates to the issue of how miners respond to nonroutine and potentially fatal situations. This effort will result in the conceptualization, development, and field testing of training treatments that encourage competency in problem solving. A draft latent image mine emergency simulation exercise was developed, authenticated, and prepared for field evaluation. The exercise, entitled "Travel Through Smoke," was designed both as a research tool to provide information about the proficiency of workers in planning an escape from a mine fire, and as a teaching device to improve miners' decision making skills. The simulation exercise presents several important decision making points that are based on actual events reported by miners who have escaped mine fires. The exercise stresses the importance of: 1) obtaining adequate information on the location of the fire; 2) donning one's SCSR at the first sign of smoke; and 3) travelling as far as possible on the mantrip through smoke (in the primary escapeway) before moving to the alternate escapeway and continuing egress out of the mine on foot.

New Mining Technology

Since Mine Health & Safety and Mine Technology are directly related, and since your conference is now addressing the non-coal sector of the industry, let me share with you some interesting new developments from the Bureau's Mining Technology Program:

Concave Bit. The Bureau has developed a bit to improve productivity of continuous excavation equipment. It is essentially a replacement for the point attack bit and can be used on all equipment currently using drag bits. This bit, called the concave bit, promises greater productivity, uses less force and energy, has symmetrical wear, and long life.

The concave bit is named for its concave face. The circular front, concave face and circular shank are the bit's main features. It uses the same bit holder as the point attack bit, and can be used on the existing heads without changing the lacing. The point attack bit breaks out the material between bits; whereas, the concave bit planes off the entire surface. The concave bit penetrates deeper with the same force; therefore, it consumes far less energy per unit volume than the point attack bit. The entire periphery is the cutting edge since the concave bit inherently rotates. This rotation yields symmetrical wear and long life.

The Bureau has successfully tested prototype concave bits with carbide and tool steel cutting edges in the laboratory. The concave bit dramatically out-performed the

point attack bit under all test conditions particularly during shallow-depth cutting. The concave bit always cuts at optimum efficiency; whereas, different bit spacings are required for every depth for optimum conventional bit performance. These dramatic results have stimulated the solicitation of the mining equipment manufacturers for a partner to complete the development of the concave bit for the U.S. mining industry. The Bureau has received several applications for license of the patent.

Waterjet Mining. The primary advantage of waterjet mining is the ability of the jet to concentrate a great amount of energy on a small target. It also has the potential for remote mining, because the energy can be "piped" for long distances. These characteristics are embodied in the borehole miner. This tool, which operates through a single borehole, uses a water jet to erode an underground cavity, while an eductor pumps the resulting slurry to the surface. After the minerals are removed, waste material can be pumped back into the cavity to complete a cycle that is environmentally compatible. This system has been successfully tested in oil sand, uranium ore, and phosphate ore.

Another waterjet adaptation is the abrasive jet. The introduction into the jet steam of a granular abrasive material, such as silica sand, enables the jet to cut at a pump pressure considerably less than that required by a straight water jet. The Bureau-designed abrasive jet can cut hard rock or steel-reinforced concrete while operating as either a drill or slot cutter. The Bureau system is being licensed by a commercial firm.

SUMMARY

I appreciate the opportunity to share with you my perspectives as to the status of the minerals industry and the Bureau. As noted, the industry will continue to see economic and regulatory pressure. Through the utilization of new technology, developed by the Bureau and others, the industry will continue to grow and address these challenges.

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