Eagle Mountain, modelling and mining

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Introduction

In 1980, Fording Coal Limited started conceptual planning studies which led to major changes in the long-range mining plan at their Fording River Operations. These new plans have been completed and are now in operation.

To assist personnel in a timely completion of this major revision to the long-range plan, existing in-house drill hole data base and scheduling systems were used and a computerized Mine Modelling and Planning System was purchased. With these tools, plans were developed which led to completion of initial access to the peak of Eagle Mountain and the start of mining operations in March 1983. As mining areas open up and new geological data is obtained, detailed plans are being extended and revised.

With the geology and mine plans on-line, this work can now be done with less effort and plans can be adapted to provide flexibility in mining operations. Changes in market conditions can be accommodated by moving mining operations into different seams for different coal types. The computer systems are used to revise pit designs and schedules accordingly.

Property Layout and General Geology

The minesite is located in southeastern British Columbia, approximately 8 km west of the Alberta border and 140 km north of the United States border. The mine area consists of two north-south-trending synclines, one on each side of the Fording River, with over ten mineable seams occuring within the 800 m thick coal-bearing Kootenay Formation. This project deals with the eastern (Alexander) syncline on Eagle Mountain. Thrust faulting has repeated the east limb of the Alexander syncline twice.

Coal seams range from medium to high volatile, increasing upward in the stratigraphic section. This gradation provides zones of similar coals which make up the three different product blends of metallurgical coal.

Topography on Eagle Mountain has as much of an influence on mine plans as the complex geology. Large elevation differences make initial access and haulroads for waste and coal difficult to build, and pre-stripping is on the mountain peak or sharp ridges. Initial waste dumps are built on coal barren areas on the steep valley walls below the lowest coal seams until mined-out pits become available for back filling.

Planning Needs

In 1982, a feasibility study was undertaken which showed that the total operation could be consolidated into a large, efficient working area on Eagle Mountain. If initial high pre-stripping and access problems could be solved, the whole mountain was mineable by open-pit methods. Exploration and detailed planning were carried out to meet the following criteria:

- minimum cost initial and future bench accesses
- downhill and minimum length waste hauls
- coal operating faces in all coal types
- large consolidated working areas
- mining at constant strip ratios
- flexibility to meet changing market needs

A series of initial cuts have been designed and are now in production.

General Modelling

To assist the geologists and planning engineers to incorporate the results of the exploration programs and develop detailed mining plans and schedules, Medsystem (MEDS), a mine planning system, was purchased from Mintec Inc. of Tucson and was interfaced to existing in-house drill hole and pit scheduling systems.

MEDS provided the capability of modelling the deposit in three different ways.

These models are:

- *Variable Block Model (VBM)* — which stores a series of planes, in this case geological sections or topography and seam structure at bench elevations.
- *Gridded Seam Model (GSM)* — which represents stratigraphic horizons at plan view grid locations.

Jim Gray

Jim Gray graduated from The University of British Columbia in 1975, with a B.Ap.Sc. in mineral engineering. He initially worked in Australia as a contract miner and later as a geotechnical engineer for Aberfoyle in their underground tin operations in Tasmania.

In 1978, he returned to Canada and has worked at Fording Coal Limited's Fording River Operations since that time. Initially, Mr. Gray was employed as a pit engineer, followed by time spent in both the planning and operating areas. He is currently superintendent of mine engineering, supervising the mining planning, operating engineering, and geology functions at the Fording River minesite. He has been involved with the Eagle Mountain project since its inception, and also with the selection and installation of the mine planning system.

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• *3-D Block Model (BM)* — which represents data elements in the model in a three dimensional matrix.

Due to the structural complexity of Eagle Mountain, the seam locations were defined in detail by loading the geological sections into a VBM and a block model was built from it. It was felt that overthrust faulting would cause problems with a G.S.M. This procedure gave a high degree of structural detail to the block model as opposed to the statistical type model often used in metals mining.

Drillholes and Compositing

The four essential elements of the drillhole data base are:

- down-hole survey record
- header record
- geophysical log
- sample log and sample data

To develop mineable coal thicknesses from the drillhole information, true seam thicknesses were calculated and mining parameters were applied. Drill hole intersections were scanned for minimum mineable thickness and minimum removable partings, and a thickness of mining loss and dilution was applied to each seam top and bottom combination. This included the top and bottom of non-removable partings as well. The mining parameters were based on current mining methods and were varied for different seam dip ranges.

Gross seam thickness, mineable seam thickness, delivered ash and delivered specific gravity were then calculated and these composited results were stored back into the drillhole data base.

Structural Interpretation

A computer-assisted manual approach was used for initial structural interpretation because of the faulting identified in earlier work. From the drillhole system, drillhole traces were plotted on east-west sections at 100 m intervals. Drillhole traces within 65 m north and south of the section were displayed with seam intersection and seam labels. Topography was also superimposed upon the section. A first pass structural interpretation was done, identifying the fault zones and, where necessary, the drillhole system was updated with any revised seam-fault designations. Fault traces and seam footwalls were then drawn on the section and digitized into a sectional VBM and then plotted and verified.

From these initial sections, rough seam footwall structure plans were created by the system. For each section, footwall intersections at each bench were generated and posted into a plan view for each seam. Subcrops and drill intersections of the seams were then superimposed on the plot. The footwall structure contours were then manually smoothed, guided by the hole intersections and posted points. These were then digitized and loaded into a plan VBM.

In a separate exercise, topography contours at bench elevations were also digitized into the plan VBM. This information was used for creating a topography matrix in later steps, as well as defining ground surface for creating sections.

From the footwall structure contours and topography, 160 east-west sections were automatically generated at 25 m intervals. To accommodate seams ending between benches, the footwalls were automatically extended or truncated at topography or fault contacts and flat areas near synclinal axes were extended. Using a 500 m search cell, gross seam thickness from the drillhole composites was interpolated to create seam tops. These were also extended or truncated at topography or faults. If a drillhole sample could not be found within the search radius, a zero thickness was assigned to keep coal estimates conservative. The detailed sections were then loaded back into the sectional VBM.

Block Model Build

The area to be modelled was divided into 160 east-west rows and 160 north-south columns, producing 25 m square grids in plan view. Extending from 2450 m to 1700 m in elevation, the model was divided into 15 m levels producing 50 mining benches.

From the detailed 25 m sections, the gross coal volume for each block on each row was calculated by an integration routine. These values were then added row by row to the block model. Due to the close spacing of minor seams, more than one seam occurred in some blocks. Because planning requires seam qualities and identities to be kept separate, two seams were defined for each block, but any additional seams were combined with the largest seam in the block to keep the model size down. This allowed adequate resolution without losing any coal volumes and only insignificant inaccuracies in coal qualities.

Other block variables, derived from the drillhole composites, were assigned to each block using 3-D interpolation. A first pass using a 500 m search radius was used to give higher resolution where possible and then a second pass filled in any missing values for blocks with coal volumes by using zone averages. The final result is a 1 280 000 block model storing topography fraction, and bank/loose flag, as well as seam name, mineable coal fraction, ash delivered, specific gravity and in situ tonnage conversion factor for the two seams in each block.

These block values give the capability to report pit design volumes for bank and loose waste, mineable coal volume by seam, the resultant ash and specific gravity, and a conversion to in situ tonnage for geological reserves reporting. Using the composited values has enabled mining loss and dilution from seam boundaries and partings to be considered.

Planning

To produce floating cone designs, the detailed block model was converted into a condensed model which only stores clean coal fraction (based on ash delivered), and a flag for high, medium, or low volatile coal types. Using various slope angles, coal prices, and mining costs, alternate mining areas were assessed and rough pit designs were created which met the planning criteria outlined earlier. By using specialized routines to force the cones to prestrip, follow seam footwalls, or target specific volumes of specific coal types, the process was sped up.

Once a sequence of valid rough pits was created, detailed pits were designed. These were made by automatic techniques for longer term highwalls but manually designed and digitized for detailed designs. Pit designs were loaded into a VBM and then run against the block model for volume calculation. These pit reserves are now used in the inhouse scheduling system and detailed schedules are being derived.

With the changing coal market and ongoing updates in the geology, pit redesign, reserve volume updates and rescheduling are often necessary. Now with the end to end on-line planning system, these updates can be accommodated with much less effort.

Current Plan and Performance

From the modelling exercise, Fording has developed a long-term integrated mining plan. During 1983 to 1985, higher strip ratios on Eagle Mountain were offset by low strip ratios in other areas and pre-stripping costs are being capitalized. Within six years, all of Fording's production will be from Eagle Mountain and the strip ratios will have dropped to below 7:1.

The mine models and planning system have greatly increased the speed of assessing design alternatives. Where only several manual alternatives were formerly considered, now many cases can be run. After the models are built, floating cone designs can be set up, run, displayed and assessed in hours, which manually took weeks to do. Detailed designs on-line also enable quick, higher detailed reserves calculations to be done. Changes in design and geology can also be accomodated with an on-line plan.

Current mining is now producing from the computer modeled benches and initial results are very good. Volumes from the computer compare within 2% of manual design and within 4% of actual production over large areas. Accuracy is lower for small areas. It is felt that this accuracy is within the meaningful limits of the geological interpretation. Continued experience will enable Fording to assess their results and may change the mining factors for dilution, mining loss, minimum mineable seam thickness and minimum removable partings used in compositing. Changes in mining techniques may alter this as well.

In total, the Eagle Mountain Model took over one and one-half man years to load into the computer and verify. From it, detailed mine plans have been derived and mining is now in progress. Computer modelling of the reserve area and computer planning tools have enabled mine personnel to produce accurate, timely plans.

The complete paper may be obtained by contacting Fording Coal Limited, P.O. Box 100, Elkford, British Columbia V0B 1H0.

The Material Handling Association of Quebec

The Material Handling Association of Quebec (MHAQ) was founded in March 1986. The objective of this non-profit organization is the promotion of the science and knowledge in the material handling field as well as an advancement of the material handling industry in the province of Quebec.

Membership is open to users, manufacturers and suppliers of material handling and related equipment and systems, to engineers, consultants and educators practicing in the field of material handling and to all others who are interested in the activities of this type of association.

Meetings will be held monthly with presentations on robotics, modern material handling systems, new material management techniques and other related subjects. Courses on Material Handling will commence in October 1986. Other activities such as seminars, plant tours and the Quebec championship of lift truck operators are also being prepared. The MHAQ will sponsor a major Material Handling Show to be held in Montreal in 1987.

Symposium on on-line particle size analysis

The Fine Particle Technology Group at Ontario Research Foundation is planning a symposium dealing with the applications and benefits of the continuous process monitoring of particle sizes down to a few micrometres in diameter. Whether simply providing a "real-time" measurement of particle size or functioning as a key element in a process control circuit, recent advances in the techniques for on-line particle size analysis have opened new opportunities for improved process technology. A wide variety of industries have the potential to benefit from applying on-line particle size analysis; for example, mining, drilling and petrochemical industries, plastics and rubber processing, pharmaceutical and food products, crushing, grinding, milling and blending circuits, pulp and paper industries.

The Symposium is intended to fully inform those industries considering the use of on-line particle size analysis as well as to provide a complete and up-to-date information base for the few who have had experience with such systems. Topics will include:

- The Sampling of Feedstreams
  Wet and dry particles, preprocessing such as dilution and classifying
- Instrumentation
  Automated "standards" and laboratory equipment, process control equipment
- Incorporating On-line Analysis in Industry Process considerations, economics

Plant managers, process engineers, quality control supervisors, and R&D and product developent personnel will find this Symposium to be benefit.

The Symposium will be presented on **November 3-4, 1986** at the Delta Meadowvale Inn, Mississauga, Ontario.

To receive further information, please contact: Dr. H.G. McAdie, Ontario Research Foundation, Sheridan Park Research Community, Mississauga, Ontario, Canada, L5K 1B3; Tel.; (416) 822-4111.

National Research Council and University of Sherbrooke join in technology transfer

The National Research Council (NRC) and the University of Sherbrooke are participating in a joint program to increase the use of technology by Canadian industries.

A new technology transfer office at the Sherbrooke, Quebec, campus, officially opened on June 19, will actively promote industrial applications of the university's research. The office will determine the industrial potential of university research and inventions and then transfer this technology to the private sector.

The university office will work in collaboration with an NRC Industrial Technology Adviser (ITA) in a new office also located at the university. The NCR's technology advisers work directly with industries to help solve technology problems.

The NRC through the Laboratory Network of its Industrial Research Assistance Program will provide funding of up to $145,000 over the next two years for the university technology transfer office. The University of Sherbrooke will pay the balance of the cost for the new office.

The office will identify Canadian companies which could take advantage of University of Sherbrooke research which could assist in developing manufacturing techniques, processes and products. In some cases, the university will participate in market analysis for its technologies.

The office will maintain and commercialize the "intellectural property" rights of university researchers, such as patents, copyrights and other expertise.

The NRC contributes more than $70 millon a year to technology transfer projects. Industry contributes matching amounts. More than 500 Canadian companies annually match their needs with expertise from the National Research Council, other government agencies and Canadian universities.

The NRC's ITA office in Sherbrooke is the twenty-fourth such operation in Canada, aimed at exploiting technology and research solutions to the benefit of Canadian industry.

Robert Simard will be the NRC Industrial Technology Adviser in Sherbrooke. Sylvain Desjardins will be the University of Sherbrooke technology transfer officer.

For further information, contact: Robert Simard, Industrial Technology Adviser, (819) 565-4932; Sylvain Desjardins, University of Sherbrooke, (819) 821-7555; John Wildgust, Public Affairs, National Research Council, (613) 993-4868.