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MINING DEMONSTRATIONS AND LONGWALL MINING SYSTEMS

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MINING DEMONSTRATIONS AND LONGWALL MINING SYSTEMS

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ABSTRACT

One approach to making new technology available is to demonstrate its value under full-scale operating conditions. Recently, studies were undertaken to assess the feasibility of this approach to introducing a longwall mining system to the western Canadian coalfields.

The longwall method of mining coal is described, world and Canadian usage is reviewed, and the merits of the system in comparison to other coal mining methods are discussed.

The rationale for a longwall demonstration in western Canada is presented, along with a proposed organization for the design, operation and dissemination of the findings from such a trial. The factors which must be considered in the design of the demonstration, and in the assessment of a potential site are highlighted. It is concluded that a demonstration of this technology is both timely and essential to prepare the way for the western Canadian coal industry of future prospects for coal.

DÉMONSTRATION D'EXPLOITATION MINIÈRE ET EXPLOITATION PAR LONGWALL

RÉSUMÉ

Le transfert de technologie peut se faire de plusieurs façons. On peut en particulier démontrer la valeur d'une nouvelle technologie dans des conditions réelles d'exploitation. Des études ont été entreprises récemment pour évaluer la faisabilité de cette démarche en ce qui concerne l'introduction d'un système d'exploitation par longwall dans les gisements de charbon de l'ouest canadien.

La méthode d'exploitation par longwall est décrite, l'utilisation de cette technique dans le monde et au Canada est examinée ainsi que les mérites du système comparés à ceux d'autres méthodes d'extraction du charbon.

Les principes sous-jacents d'une démonstration d'exploitation par longwall dans l'ouest canadien sont présentés, ainsi qu'un projet d'organisation pour la conception et la mise en oeuvre d'un tel essai et pour la diffusion des résultats. Les facteurs à considérer dans la conception de la démonstration et dans l'évaluation d'un site potentiel sont mis en évidence. On conclut qu'une démonstration de cette technologie est à la fois opportune et essentielle pour ouvrir de nouveaux horizons à l'industrie du charbon de l'ouest canadien.

INTRODUCTION

For many years CANMET has encouraged research work organized on a cooperative basis. This requires that a working concensus must be negotiated by researchers and operators at the beginning of the project and continuously refined as work proceeds. The result is usually a more relevant selection of research problems, improved direction and conduct of experimental work and often a validation phase in which research concepts are tested in an operating environment. All this tends to narrow the gap between obtaining research results and applying them.

Even under the best of circumstances cooperative projects require a good deal of coordination and enthusiasm to maintain focus and the pace of work. The working perspective of a research scientist in a government laboratory is substantially different from that of a mine operator at a producing mine, and a common ground must be found. This is difficult to do and cooperative projects typically evolve over several years as experimental results progressively define the potential solutions to mining problems.

Not all mining problems need to be examined in such detail. The international knowledge base of mining technology is already very large. Where international practice is adequate and the need for a solution is urgent, demonstration rather than research can be both practical and economical.

This situation was perceived to exist in western Canada in 1980. There was a need for a safer, less labour intensive and more productive method of mining underground coal so that the coal industry would be able to participate in the expanding export markets for coal. The solution was seen to be the introduction of the mechanized-longwall system of mining to western Canada and mining demonstration was chosen as an approach.

Some progress has been made in establishing the longwall demonstration and in focusing attention on the issues that must be resolved if demonstrations are to become a practical approach to introducing new mining technology.

1.0 MINING DEMONSTRATION

"Mining demonstration" is used here in the particular sense that the project is partly financed by public funds. This implies that there is an identifiable public purpose to be served and that this will be reflected in the objectives and conduct of the project.

Since there are no Canadian precedents there are few standards. We are learning by doing and hence keeping an open mind on any procedures to be adopted.

Obviously a mining demonstration must produce coal and the responsibility to do this within the regulatory requirments lies with the project operator. He needs scope to act. Equally clear are the various sponsors' requirements. They must obtain value for their investments. In general the sponsors' need is for reliable information. What mechanisms should be adopted to ensure that both requirements are met and more specifically how much effort should be devoted to obtaining information for the next project as distinct from evaluating the performance of the existing one are the critical matters.

United States experience with mining demonstrations is somewhat more extensive and mention should be made of two active projects. Steep seam longwall is being demonstrated at the Snowmass Coal Company near Carbondale, Colorado. Three adjacent panels are to be mined over a period of five years beginning in 1981 in a two meter thick seam dipping at 30°. Multi-lift mining is being introduced at Mid-Continent Resources, also of Carbondale, Colorado. Seven panels, four in the upper lift and three in the lower, will be mined at the top and bottom of an 8.5 meter seam leaving a 1.5

meter partition between seams. The lower lift will be mined two to three years after the upper lift and the life of the project is estimated to be 10 years. Each of these projects has secondary features e.g. entry support, methane drainage, variable overburden cover, etc. which could be of overriding interest to some other operators.

Assuming the necessary pre-conditions exist, i.e. a significant problem, available technology and a successful project, the merit of the demonstration approach seems to be:

- credibilility and hence wide applicability of findings is very high.
- delivery time for fully useable technology is shorter.
- unit cost of information is low to the industry as a whole.

The great disadvantage of the approach is that total project costs are high, so wide agreement is needed to initiate work and this is often difficult to achieve.

2.0 THE LONGWALL MINING SYSTEM

2.1 BASIC SYSTEM

The longwall mining system, in its simplest form involves the extraction of large blocks of coal in a single continuous process. The extraction can be either an advancing or retreating operation. In the advancing method, the coal is worked away from the main entries into virgin ground, the face roadways being made in the mined out area behind the coal face. In the retreating system, the block of coal to be mined is outlined by developing the roadways first, out to the limit of the block, and then retreating the faces back towards the main entries. (see Fig. 1).

Advancing longwall mining offers the following advantages: (1) quick startup of full production, and (2) shorter entry service life, because the entries do not have to be ready before the mining process begins. The disadvantages are: (1) high cost for packwalls; (2) abutment pressures have a full impact on the entries, possibly leading to excessive entry support and maintenance problems; and (3) methane liberation may be higher, because no bleeding has taken place during the entry development process and the danger of spontaneous combustion from air leakage through the packwalls into the sealed gob area is greater.

Retreating longwall mining has the following advantages: (1) it reduces entry maintenance, because the entries are abandoned shortly after they come under the influence of the forward abutment load; (2) it allows proper bleeding of the gob area (3) it reduces the danger of spontaneous combustion; (4) it assures that entry development will not hinder the face operation and allows positive control of the ventilation; and most important (5) it provides advance knowledge of geological conditions. Its disadvantages include: (1) the development of entry systems in advance of the mining operation causes a delay in initiation of production, and (2) under unfavorable conditions (soft bedrock, thick overburden), a considerable number of entry maintenance problems may be experienced before full production starts.

The number of face roadways required to service a longwall face varies according to the mining regulations and custom and practice in each country. For example, in the U.K. only one roadway at each end of the face is necessary, in the U.S.A. usually three as a minimum; in Canada in N.S. one, in western Canada it is expected to be two but since there are no longwall faces in operation, the minimum requirements have not been firmly established.

The typical components of a longwall face, whether advancing or retreating as shown in Figure 2 are:

(i) A coal cutting machine(s), usually a shearer.

(ii) A flexible chain conveyor (AFC) which transports the cut coal along the face; provides a track for the shearer to travel upon; often incorporates the structure which the shearer uses to haul itself along the coal face, and which forms the anchorage against which the powered supports advance themselves.

(iii) Powered hydraulic supports (including an electro/hydraulic power pack) which support the length of the face.

(iv) Modified powered supports for use at the ends of the face.

(v) A chain conveyor or 'stage loader' situated in the main gate roadway which transfers the coal from the face AFC to the main gate belt conveyor.

(vi) A belt conveyor in the main gate which travels the length of the mining panel, and transports the coal to the main haulage system of the mine (usually conveyors or mine cars and locomotives).

(vii) Electrical equipment to power and control the above equipment.

(viii) Communications and signalling equipment.

(ix) Face lighting systems.

It must be appreciated that there are numerous variations and alternatives possible and indeed necessary to meet the many mining conditions found throughout the world.

Figure 3 illustrates the typical layout for an underground mine working both longwall and room and pillar system.

2.2 WHY LONGWALL?

As a mining system longwall mining has, compared with the room and pillar system, many advantages and also some disadvantages. These can be summarized as:

Advantages

(a) Safer environment - better protection from roof falls and haulage accidents.
- better and easier ventilation.

(b) Higher recovery of resources - between 60% and 80%.

(c) Higher production and productivity.

(d) More applicable for deep mining.

(e) Permits better control of strata in the mine and surface subsidence.

(f) More efficient for multi seam mining.

(g) Easier system to automate and monitor.

(h) Requires less development per tonne mined.

(i) Lower capital cost per tonne mined.

(j) Capable of mining coal in difficult mining conditions:

- weak strata above and below the seam
- seams disturbed by previous mining
- steeply pitching beds (up to 55°)
- deep coal (1300 m)
- thin coal (1.0 m)

Disadvantages

(a) High initial capital costs.

(b) Face transfer problems. Lost time can be between 4 and 6 weeks so standby production facilities necessary.

(c) Transportation of heavy components require special attention.

(d) Sensitive to panel development rates and coal clearance delays.

(e) More easily affected by geological disturbances.

2.3 OPERATIONAL CYCLE

As with most mining systems there are several operational modes. In this system, they are related to the timing of the movement of the roof supports after the coal cutting machine has passed that point on the face, and to the use of advancing or retreating mining systems.

The original practice, which is often called the "conventional" method simply calls for the face conveyor to be advanced immediately after the shearer has passed, and the roof supports advanced as close as possible to the working face immediately afterwards. This reduces the width of the immediate roof which has to be supported by the main roof supports. Unfortunately it also limits the area that is available for the work force to travel in or work in (Figure 4a).

An alternate is the "One web back" method where the roof supports are moved over to support the newly exposed roof immediately the shearer has cut passed but before the conveyor is advanced. This allows the work crews approximately 0.6 m more

room to travel and work in and tends to aid productivity and in some instances working conditions (Figure 4b).

Bearing in mind the differences between these two methods, the basic cycle is: the coal getting machine(s) removes a slice of coal along the whole length of the face (either uni- or bi-directionally) loading the coal onto the face conveyor (AFC). The face conveyor is advanced by hydraulic rams, and the hydraulically powered roof supports lowered, advanced and reset one by one, following the advance of the conveyor in the first case, or afterwards in the alternate case. As the supports move, the roof behind them is allowed to cave (Figure 5).

2.4 MANPOWER LEVELS

These will vary according to the length of the face, the method of mining - advance or retreat - and the layout of the mine. However, a typical manpower requirement for a retreating longwall face working three consecutive shifts plus a maintenance shift will be

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Operation	Production Shift 1	Production Shift 2	Production Shift 3	Maintenance Shift
Machine Operators	2	2	2	1
Roof Support Operators	3	3	3	-
Face End Workers	4	4	4	-
Mechanics	2	2	2	2
Electricians	1	1	1	2
Stage Loader Operator	1	1	1	-
Face Supervisor	2	2	2	1
	15	15	15	6
			TOTAL	51

2.5 OUTPUT, PRODUCTIVITY AND MINING LIMITS

Output and productivity figures are obviously very site specific, however the longwall mining system produces higher unit outputs and face productivities than room and pillar mining. Longwall face productivities usually average twice those from room and pillar sections.

Figure 6 shows how average outputs per shift from longwall faces vary with seam height. It is interesting to note that the current world record output is over 9,000 tonnes in a day from a 3.6 m seam.

Longwall mining is at its most efficient in seams up to 5 m thick and gradients up to 20°, although gradients up to 55° are currently being worked in Europe, and in conjunction with a sub-level caving adaption, seams up to 30 m thick are also being worked in both East and West Europe. Longwall face lengths usually vary from 50 m to 250 m, panel lengths from 1000 m to 2000 m, and mining depths from 60 m to over 1000 m.

In the thick steeply dipping coal deposits, hydraulic mining with gravity or slurry pumping coal clearance systems is by far the most suitable method offering face productivities up to four times those of longwall mining.

3.0 NEED FOR A LONGWALL DEMONSTRATION

The longwall mining system is extensively used in Europe (U.K. France and Germany in particular). Where, because of adverse natural conditions such as deep seams and weak strata, it is frequently the only practical method. Over 95% of deep mined European production comes from the application of this method, whereas in the U.S.A. the equivalent figure is less than 5%.

In Canada, longwall mining is currently only practised in Nova Scotia where mining conditions are broadly similar to British conditions. Longwall production in Nova Scotia accounts for about 5% of the total Canadian coal production.

Longwall mining was attempted in western Canada in 1969/70 at the Smokey River mine of McIntyre Mines in the mountain coal region of Alberta. These attempts using standard British mining equipment were not successful on the two faces which were operated. The major causes for failure were design and stability problems with supports which coupled with a very soft floor resulted in inadequate ground control. Additional factors were installation delays, methane emissions and management philosophies.

Since that time, face equipment designs and technology have improved extensively, transportation systems capable of rapidly handling the heavy face equipment are now available, and considerably more is known about underground mining conditions in the mountains.

There are substantial bodies of underground mineable coal in western Canada in the mountains, foothills and plains regions, much of which is probably suitable for the longwall mining.

However these coals present a different set of mining conditions to those normally found where longwall mining is extensively practiced. Plains coals have weak roofs and floors, and are subject to seam height variations, whereas mountains and foothills coals tend to be more disturbed and folded, have more severe gradients and changes of gradient, and the strata are subject to the residual mountain building stresses.

It is encumbent upon every industry to use the best tools for maximum efficiency and economy. The longwall mining system offers the mining engineer the opportunity to mine coal at high output levels and high productivities but also in a very safe manner. Unfortunately, the capital investment required is extremely high (up to $12M depending on site specifications). This, combined with the more and arduous mining conditions in western Canada, point to the need for a longwall demonstration project. Such a scheme would reduce the risk to the mine operator whilst ensuring that the information generated during the demonstration would be available to other interested mining companies, to the obvious benefit of the coal mining industry in general.

In certain western Canadian coalfields, the presence of the weak roof strata highlights the question of the stability of mine roadways particularly where retreat mining is being considered. The drivage and support of such roadways is another area where further investigation - possibly by demonstration - is required.

3.1 WORLD USAGE

The longwall mining system was developed in Wales in the early 1700's based on a hand got mining system. The mechanised longwall face system dates from the late 40's and early 50's with the introduction of the plough in Germany and the shearer in England, and in the mid-fifties, the hydraulic powered support also in England.

At the present time, the longwall mining system is in use in every major coal mining country in the world. Its predominant use, is naturally in those countries in which it evolved, namely U.K., W. Germany and France. The data given in Table I confirms that fact.

It is interesting to note that in the countries where longwall mining is relatively new, the projected usage for the system is very good. For example, in the U.S.A. the number of longwall faces is expected to grow from 112 in 1981 to over 250 by 1985.

3.2 THE FUTURE FOR CANADIAN COAL

We do not consider ourselves to be capable of forecasting the future, rather we have relied on the experts in that field. The present world recession has, of course, upset most of the predictions for the future of Canadian coal, but even though expansion may have delayed a few years, there is no doubt that the Canadian Coal Industry will have to dramatically increase its output in the future.

Figure 7 summarizes some of the future expectations for the Canadian Coal Industry, firstly the high and low cases presented in 1980, and the high and low cases presented by another author at this conference.

4.0 DESIGN, ORGANIZATION AND FINANCING

4.1 DESIGN CONSIDERATIONS

There are a multitude of factors which have to be taken into consideration in planning both a standard longwall mining face and a demonstration longwall face.

The major factors common to both are briefly listed below. A more detailed listing will be found in Reference (1).

(a) Geological Factors

1. Reserves must be adequate (minimum 8 years).
2. Area relatively free of wells and surface features requiring coal pillars to be left for protection.
3. Cavability of strata. For effective roof control, roof strata within two times and five times the seam height should cave readily and bulk satisfactorily.

4. Floor strata must have adequate bearing strength to transfer loads from face roof supports which in turn have to carry weight of immediate strata within pressure arch.

5. Seam gradients and variability.

6. Depth of workings (affects pillar sizes).

7. Subsidence at surface or in seams at higher level.

8. Likely presence of water.

9. Methane emission rates.

10. Liability to spontaneous combustion.

(b) Operational Factors

1. Mining Method - Advance or Retreat.

2. Seam height.

3. Equipment capacities, compatibility and reliability.

4. Panel length related to frequency of face moves and hence lost production (up to 20 days).

5. Methods and rate of panel development.

6. Need for standby face or spare production capacity.

7. Number of production shifts per day and week.

8. Uni- or bi-directional cutting and use of conventional or 'one web back systems' related to depth of cut.

9. Coal clearance systems.

10. Transportation systems - supplies, men and heavy equipment.

11. Availability of suitable trained labour.

(c) Economic Factors

1. Capital Cost - usually dependent on:

(a) Face length

(b) Seam height

(c) Panel length

(d) Sophistication of control and monitoring

(e) Equipment life

(f) Mining method and development

2. Operating cost.

3. Profitability - evaluated on the basis of return on investment (ROI)and cost per tonne produced. (For both capital and operating costs.) Figures 7a and b give typical figures.

In addition to the above basic factors, a proposal for longwall demonstration faces needs to consider the following:

1. Expertise in design and management must be made available with experience of longwall mining in conditions similar to those expected for the demonstration faces.

2. Mining layouts should present the most favorable conditions for the first face with particular regard to panel

orientation, mining height, face length, development layout and coal clearance and transportation systems.

3. Panel layouts should where possible be designed to permit longwall faces to be mined in both virgin areas and adjacent to mined out areas, i.e. offer the variety of conditions normally found in underground longwall mining.

4. The demonstration should encompass the mining of at least three longwall panels so that the effects of face moves, equipment repair and maintenance, and equipment life, can be properly assessed, as well as providing sufficient mining capacity to reach full production after initial training and learning curve problems.

5. The design of the longwall face must take into consideration the need to observe, measure, change and record data from the operations in order that effective assessments can be made of the system, and data provided for dissemination to other potential users.

6. It must be recognised by the mine management and the other partners, that the operation of a demonstration project does

place some restrictions on potential output, and on freedom of action, if the purpose of the demonstration is to be achieved. That is, the acquisition of data and the proving of the mining system in the specific site conditions. It would not be wise, for example, to commit the longwall production at a 100% normal rated capacity, to meet a sales contract requirement.

4.2 DATA COLLECTION

Operating parameters should be developed before the project starts and in such a manner that they can be changed in the early stage of trials to respond to the conditions encountered. Experimental data must also be developed and carefully interpreted immediately it is available particularly during the initial start-up period to allow adjustments to be made as necessary. Once the longwall system is functioning satisfactorily, extensive and accurate technical, economic and environmental data must be acquired using suitable data collection and monitoring systems. This data, when fully analyzed should provide the basis for the design and development of future longwall systems.

Because a longwall system is very dynamic by nature, electronic data acquisition systems to monitor the various parameters on a continuous basis are desirable. To simplify installation, maintenance and control, as many of the transducers as possible should be installed as integral parts of the longwall system's basic and normal components. A detailed time study should be undertaken, possibly continuously, to obtain data and assist in coordinating the events of interest within the various operating parameters.

The monitoring program should be divided into two phases, experimental and demonstration.

4.2.1 Experimental Phase

The data collected in this phase should be utilized primarily for adjusting the system and subsystem operating parameters and operational practices to yield optimum performance. The data thus collected should help to establish the following.

a) Roof pressure distribution profiles along the coal face.

b) Influence of any local massive sandstones on the pressure distribution and cavability of the roof.

c) Transfer and distribution of pressure in the mine floor and abutment pillars.

d) Yield rate of face supports.

e) Rate of face advance.

f) Fracture patterns and the rate of their propagation.

g) Behaviour of goafline and caving characteristics.

h) Roof stability along the entries and on chain pillars.

i) Floor pressures and "heaving" characteristics of the mine floor.

j) Water percolation through the mine roof, goaf, and mine floor, and any effects of humidity.

k) Nature and amount of power used by various machines.

l) Subsidence.

4.2.2 Demonstration Phase

Extensive amounts of data must be collected in this phase to help the design of future longwall systems in Western Canada. Basically, three types of data are required technical, economic, and environmental.

4.2.3 Technical Monitoring

The following are some of the technical items that should be monitored:

a) Rates of face advance, maximum, minimum and average.

b) Yield and loading characteristics of the face supports.

c) Surface subsidence.

d) Pressure distribution along and across longwall face.

e) Pressure distribution along the main and tail gate entries.

f) Location extent and effect of abutment pressure zones.

g) Pressures on chain pillars.

h) Optimum entry width and height.

i) Face and entry support systems.

j) Transportation requirements.

k) Energy requirements.

4.2.4 Economic Monitoring

Economic data should collected and compiled to help determine project costs and economic data for use in future longwall systems, such as:

a) Optimum production and productivity obtainable.

b) Regular and preventive maintenance requirements.

c) Equipment availability, utilization, and performance.

d) Systems and subsystems optimum performances.

e) Inventory and supplies requirements.

f) Capital and operating costs.

4.2.5 Environmental Monitoring

Environmental data should be collected and compiled to help determine the following for future longwall systems:

a) Optimum ventilation requirements to meet quality and quantity standards set by Provincial and/or Federal agencies.

b) Specifications for dust control systems.

c) Illumination requirements on the face and in the entries.

d) Noise control requirements.

4.3 CONTROL ORGANIZATION

A control organization for the mining demonstration is of absolutely vital importance. It is also difficult to predict its performance as that depends not only on the organizational structure of the organization but on the selection of people to operate it.

As originally conceived the minimal requirement was for an "overview committee" meeting say quarterly to audit progress of work, provide advice where possible, to become informed on the technology and its implementation and to diffuse this knowledge to the industry. The committee of active members was to be small, say less than ten, but representative of the widest range of groups with an interest in the success of the project and wider application of the technology. Others with a lesser interest were identified as observers.

This concept was examined in the feasibility study and an organizational structure of the type shown in Figure 9 was recommended. While the operator must have exclusive authority and responsibility for operations, the data collection and the research and development functions should, as far as possible, be independently conducted by CANMET with the collaboration of the mine operators.

The Industrial Review Committee (IRC) which is made up of the operator, CANMET and other relevant personel, should meet at regular intervals to overview the progress of the project and carry ultimate responsibility for it. The project operation committee (POC) which is made up of the operator, CANMET and other relevant personnel, should meet probably once a month, to review progress, disseminate information, generally guide the project, and help solve potential problems. The POC must be available to meet at any time if the Project Coordinator or the Manager Underground Mines feels it necessary.

The same concept examined in the engineering study recommended that a Steering Committee be established (Figure 10) on which there would be no direct representation of other operators and it would operate under the following terms of reference:

- monitor progress of the longwall trial
- provide periodic and final assessment of the project
- collate and disseminate information on the project
- approve and coordinate additional on-site research.

This committee would have reporting to it a project management group.

These formats illustrate two of the many that could be considered for a demonstration project.

Not specifically covered in any of these organizational descriptions is the contractual requirement between CANMET and the operator to account for expenditures and report results on all projects where public funds are used. This reporting requirement, including interim and final reports, is of course mandatory.

4.4 FINANCING ALTERNATIVES

The financial aspect is an important part of the project control system. This is the next stage in the planning of the project and has not yet been considered in detail. For purposes of this presentation the following alternatives might be considered:

- Operator 50%, Government 50%
- Operator 50%, Government 30%, Other 20%
- Operator 1/3, Federal 1/3, Provincial 1/3

On the basis of present information the operator would have to see sufficient benefit in a project to carry no less than a third and more likely half the project cost. The total cost of the project will be influenced by how the project boundaries are defined with respect to mine development and cost of services, as well as the financial terms that equipment manufacturers offer. There appears to be considerable scope available in determining the amount of capital at risk at any one time. This is a project specific issue and cannot be usefully addressed in general terms.

5.0 PRESENT STATUS AND PROSPECTS

The history of this project goes back to 1970 when the first attempt at modern longwall mining in western Canada was abandoned. At the time, an effort was made to establish a demonstration-research site but this was not successful and it was not until 1980 that longwall was given serious consideration again. In 1981 McIntyre Mines expressed an interest in longwall mining methods, market forecasts were optimistic and labour was in short supply. The Inquiry into Coal Mine Safety in Alberta recommended that a trial of longwall mining be undertaken.

The feasibility of establishing a demonstration site at the Grande Cache property was assessed in mid-1982(1). The engineering and system design was completed in early 1983(2). They recommended that three longwall panels be extracted over a period of about 4½ years. The top three metres of the six metre thick No. 4 seam would be mined along a face length of 168 metres and panel run of the order of 1460 metres. Sufficient reserves were identified at the No. 9G mine to double the life of the trial with no difficulty.

Nevertheless, the demonstration is unlikely to proceed as planned because of the depressed coal markets. That part of the study related directly to longwall mining technology is accessible in the contract report. The work specific to the site will serve as a useful case study but will have to be re-done for another site. The experience gained by the participants on this study is for the most part available. Interest in longwall techniques has been expressed by operators in mountain, foothills and plains coal fields. Market conditions will likely determine how quickly these interests harden into firm plans.

CONCLUSIONS

1. Demonstration of longwall mining technology is essential to prepare the way for the western Canadian coal industry's future prospects.

2. The "demonstration" approach to developing improved mining technology might be adopted as a useful strategy on other issues.

3. Support and drivage of access openings in the fragile coal measure rocks of western Canada would be a useful area of research as the access openings could be the critical bottleneck in the application of longwall systems.

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Contracts available from:

Micromedia Limited
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TABLE I

LONGWALL MINING STATISTICS FOR MAJOR USE COUNTRIES

Country	Total Production MMT (1981)	% Output From Longwall	No. of Longwall Faces	LONGWALL FACES Av.Ht. (m)	LONGWALL FACES Av. Face Length (m)	LONGWALL FACES Av. Depth (m)	Average Underground OMS	Typical Face OMS
Canada	40	5	8	2.16	213	650	n.a.	19.1
U.S.A.	700	8	112	1.78	168	350	n.a.	n.a.
U.K.	114	92	581	1.58	198	516	2.90	16.8*
W. Germany	86	94	247	1.82	223	850	4.02	18.9
Australia	92	4.5	8	3.11	140	210	10.34	n.a.
France	22	95	n.a .	n.a.	130	668	3.54	11.34
S. Africa	130	6	8	2.85	–	150	n.a.	n.a.

*The new Advanced Technology Mining Faces average 29.3 tonnes per man shift.

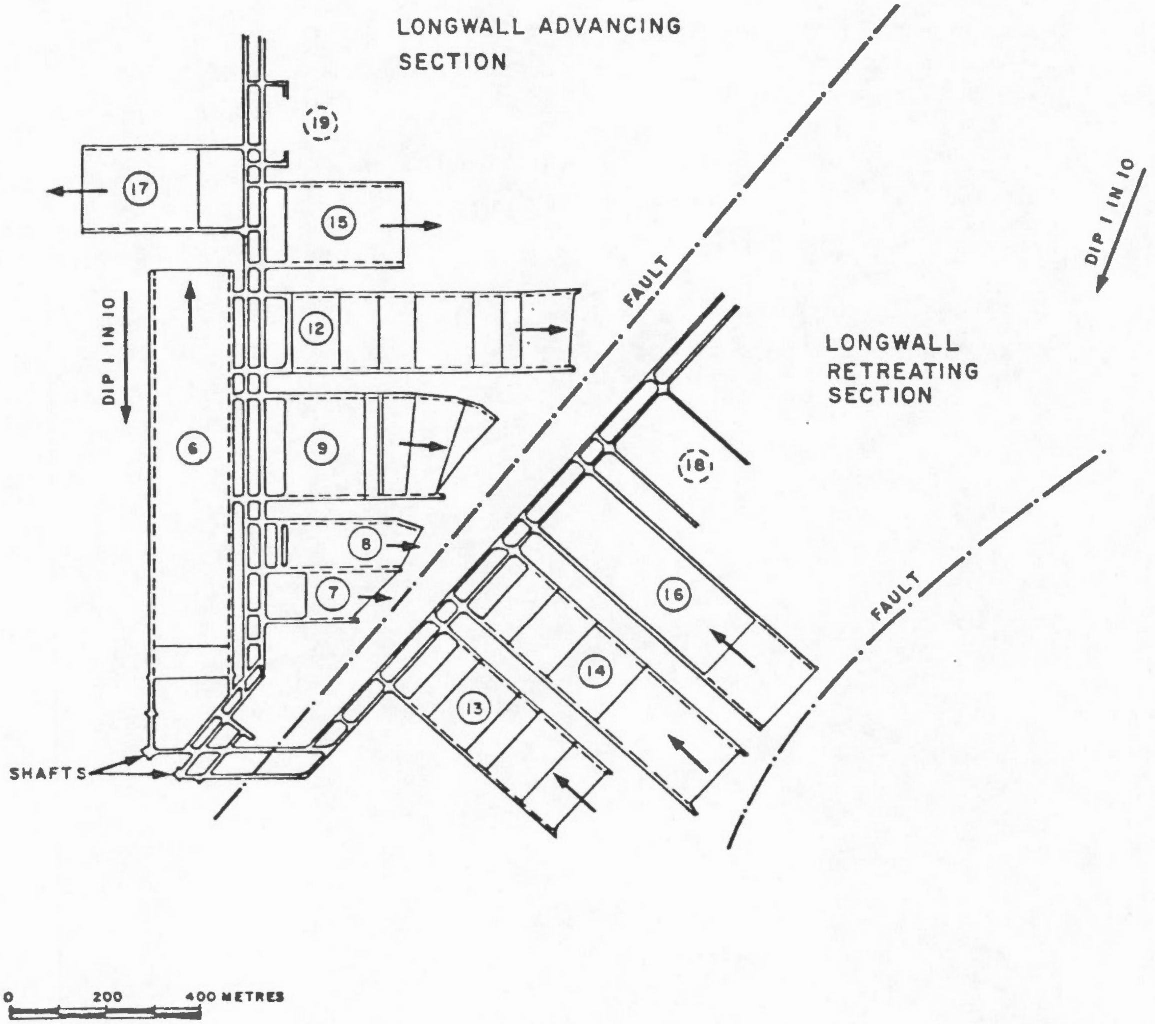


FIGURE - 1 : UNDERGROUND MINE SHOWING TYPICAL LONGWALL ADVANCING AND RETREATING SYSTEMS

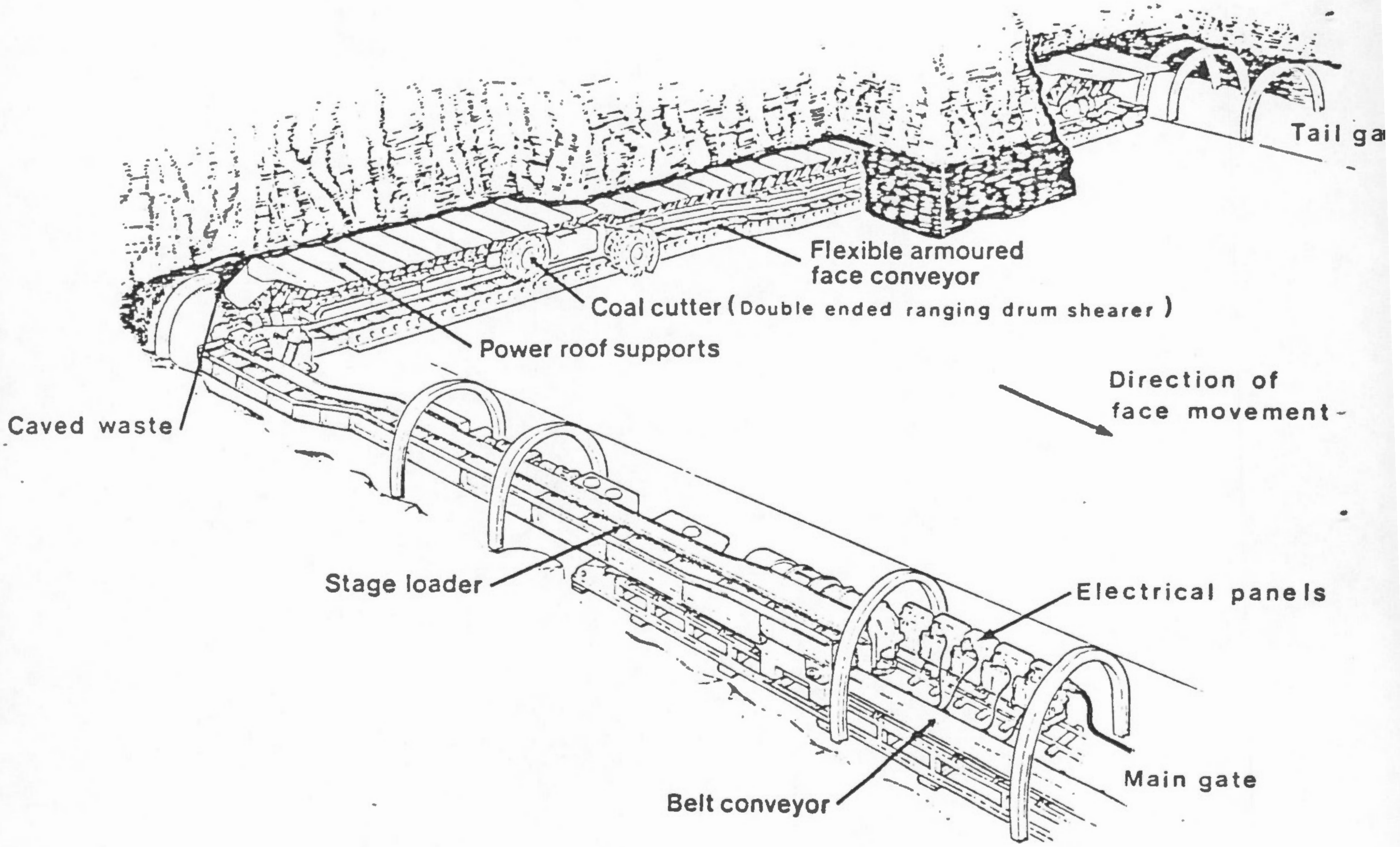
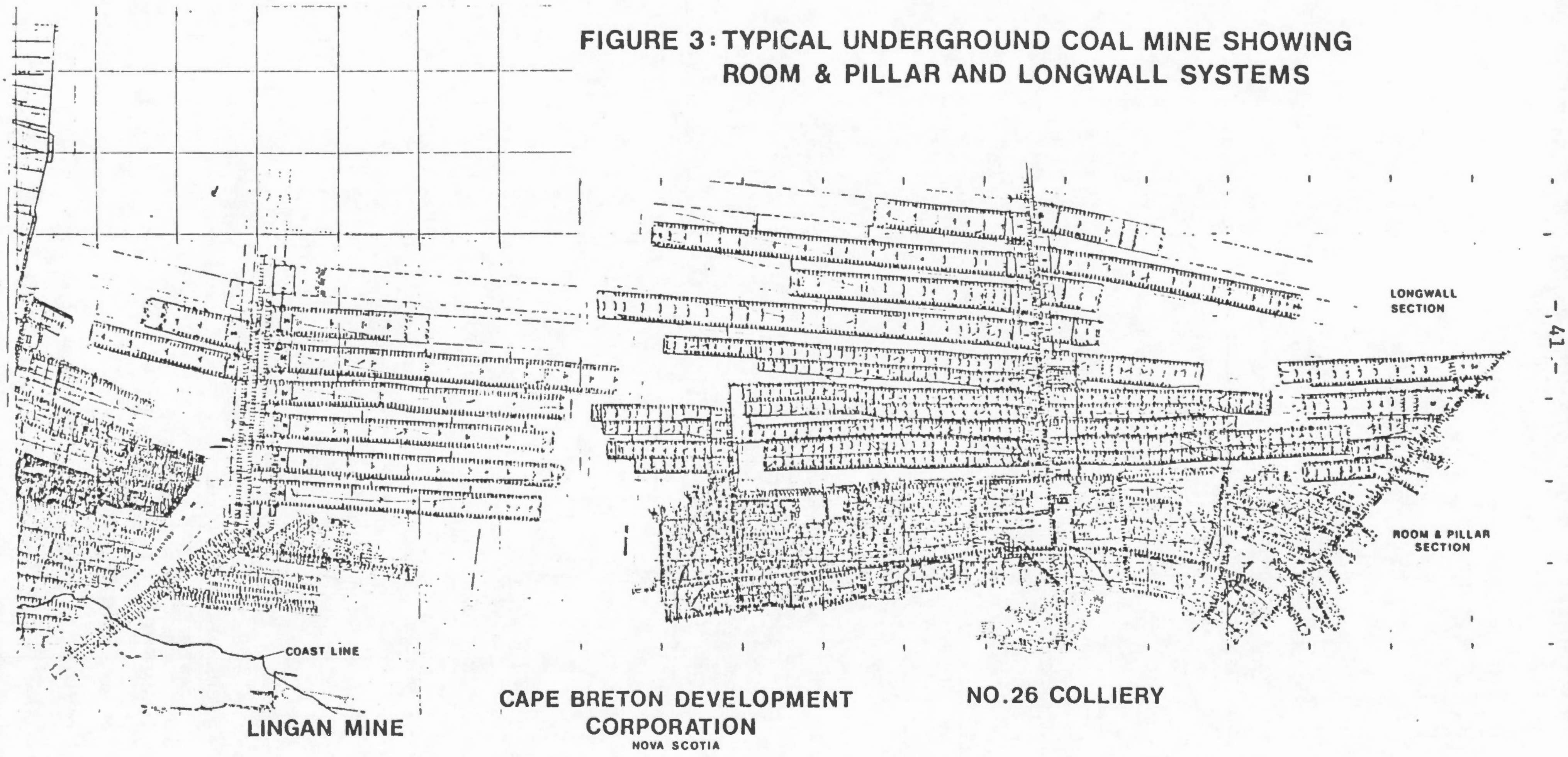


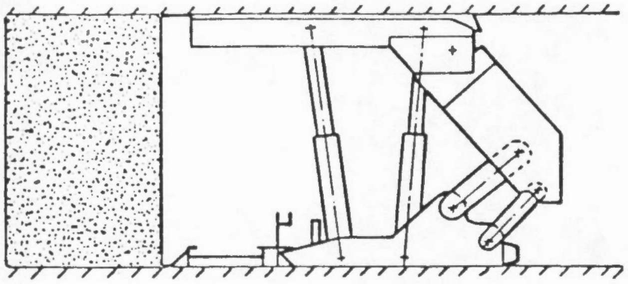
FIGURE 2: TYPICAL RETREATING LONGWALL FACE SHOWING MAJOR EQUIPMENT COMPONENTS

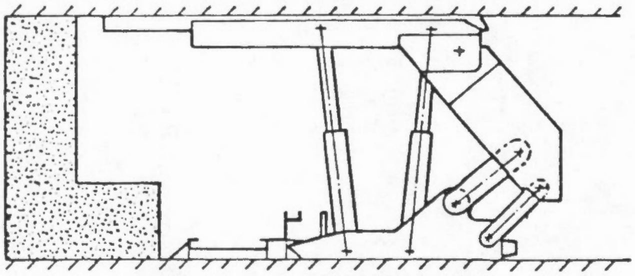
FIGURE 3: TYPICAL UNDERGROUND COAL MINE SHOWING ROOM & PILLAR AND LONGWALL SYSTEMS

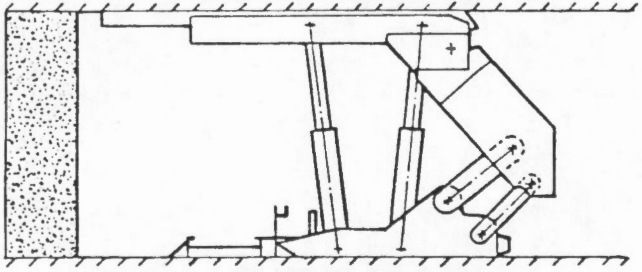


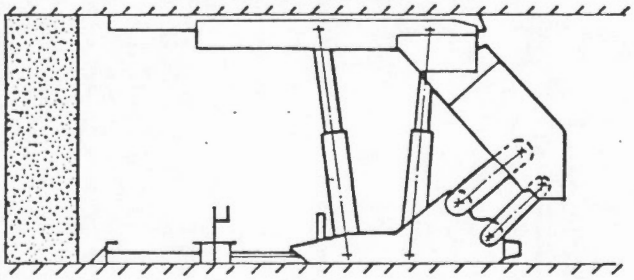
CONVENTIONAL MINING SYSTEM

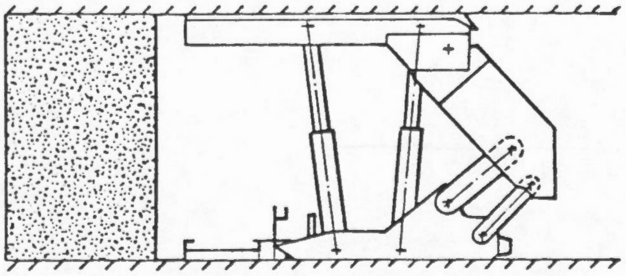
CUTTING AND SUPPORT ADVANCE SEQUENCE


1. FACE BEFORE CUT


2. DRUM CUTS TOP COAL
CANTILEVER EXTENDED


3. DRUM CUTS BOTTOM COAL
ON RETURN RUN


4. CONVEYOR ADVANCED

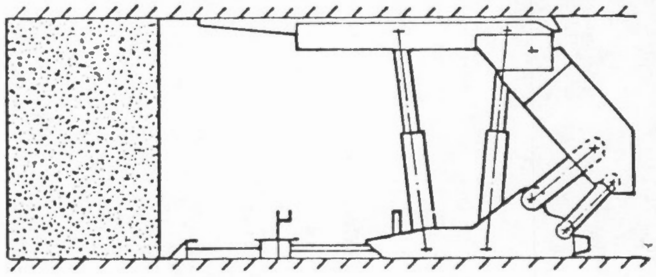

5. SUPPORT ADVANCED
CANTILEVER RETRACTED

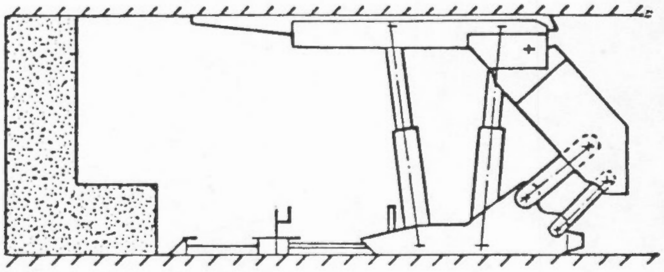
RECOMMENCE CYCLE AS IN I

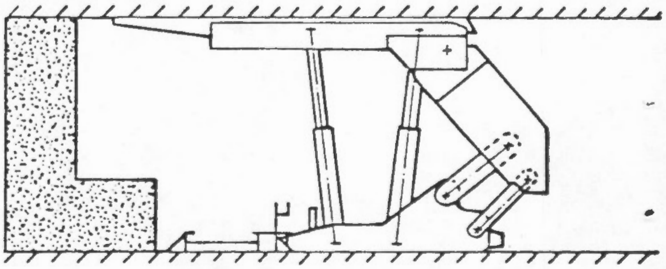
FIGURE 4a

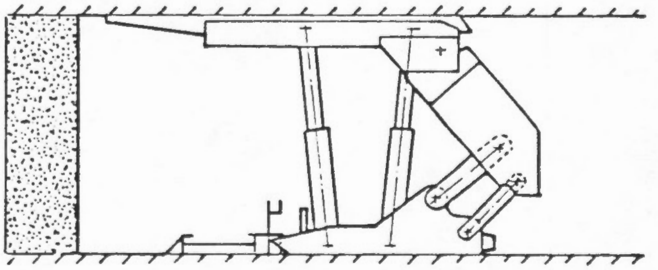
"ONE WEB BACK" MINING SYSTEM

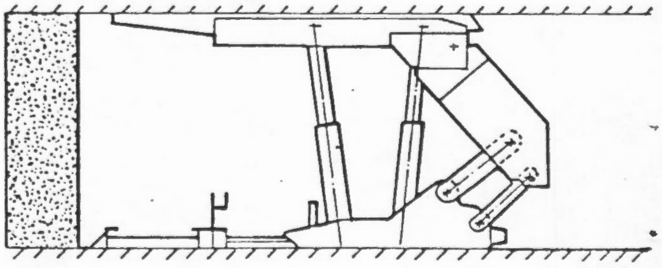
CUTTING AND SUPPORT ADVANCE SEQUENCE


1. FACE BEFORE CUT


2. DRUM CUTS TOP COAL


3. SUPPORT ADVANCED


4. DRUM CUTS BOTTOM COAL
ON RETURN RUN


5. CONVEYOR ADVANCED

RECOMMENCE CYCLE AS IN I

FIGURE 4b

TYPICAL CYCLES OF OPERATION FOR CONVETIONAL AND "ONE WEB BACK" LONGWALL MINING SYSTEMS

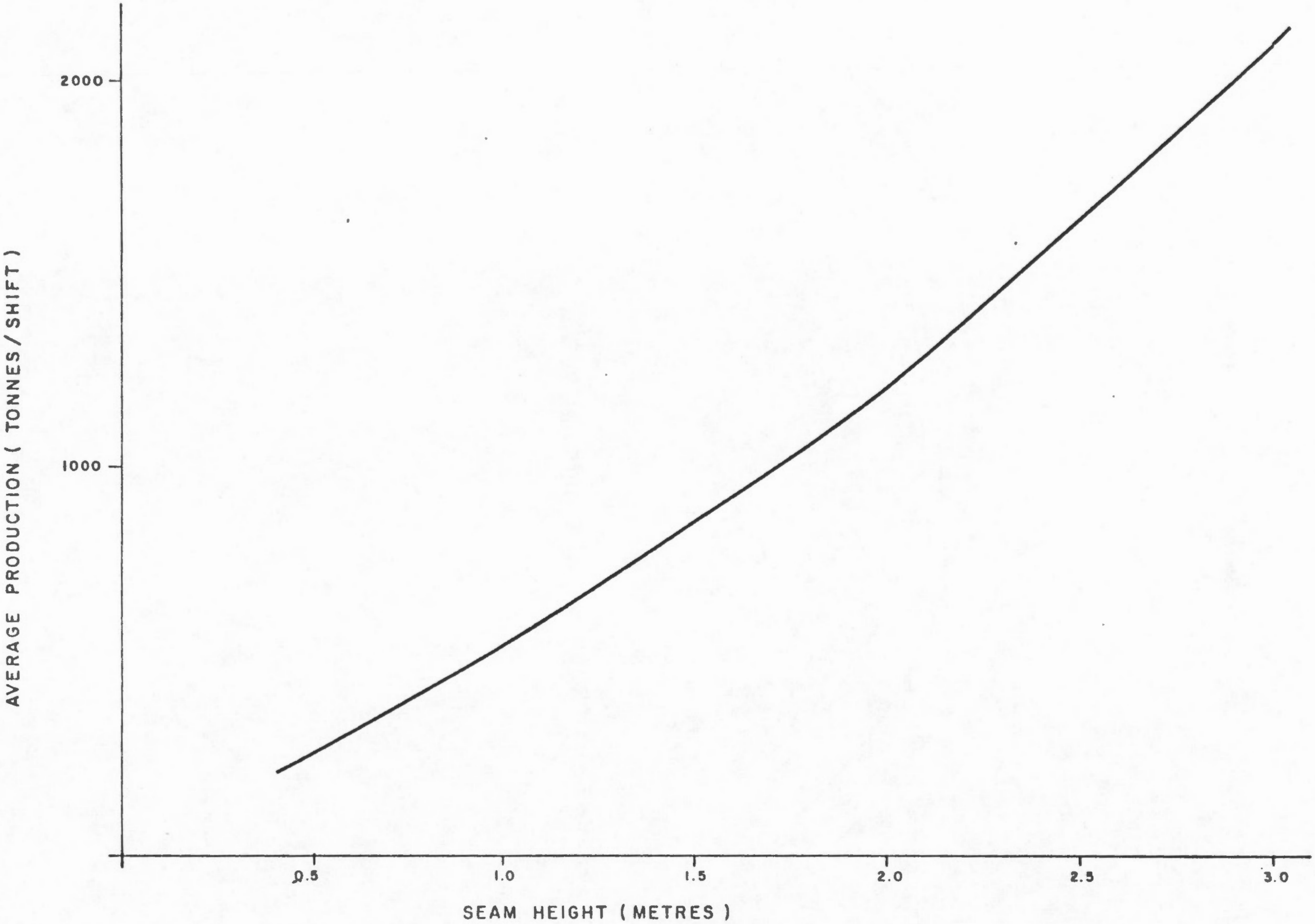


FIGURE – 6 : RANGE IN AVERAGE OUTPUTS FOR LONGWALL FACES AT VARYING SEAM HEIGHTS

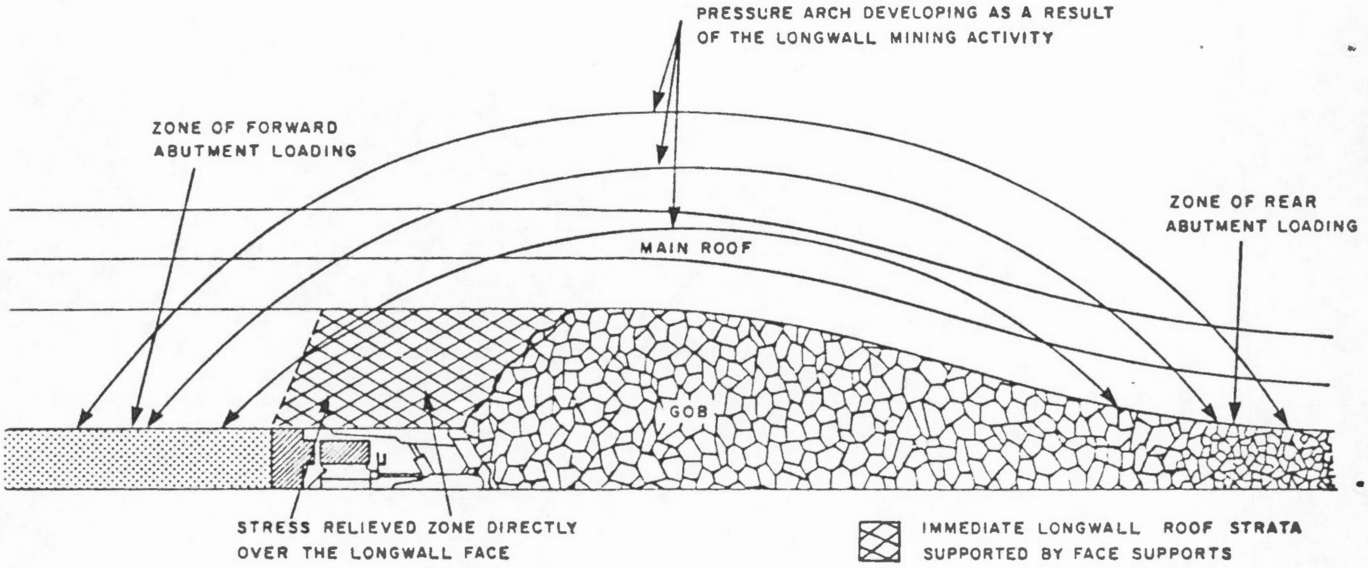


FIGURE-5: CROSS SECTION THROUGH AN ACTIVE LONGWALL PANEL

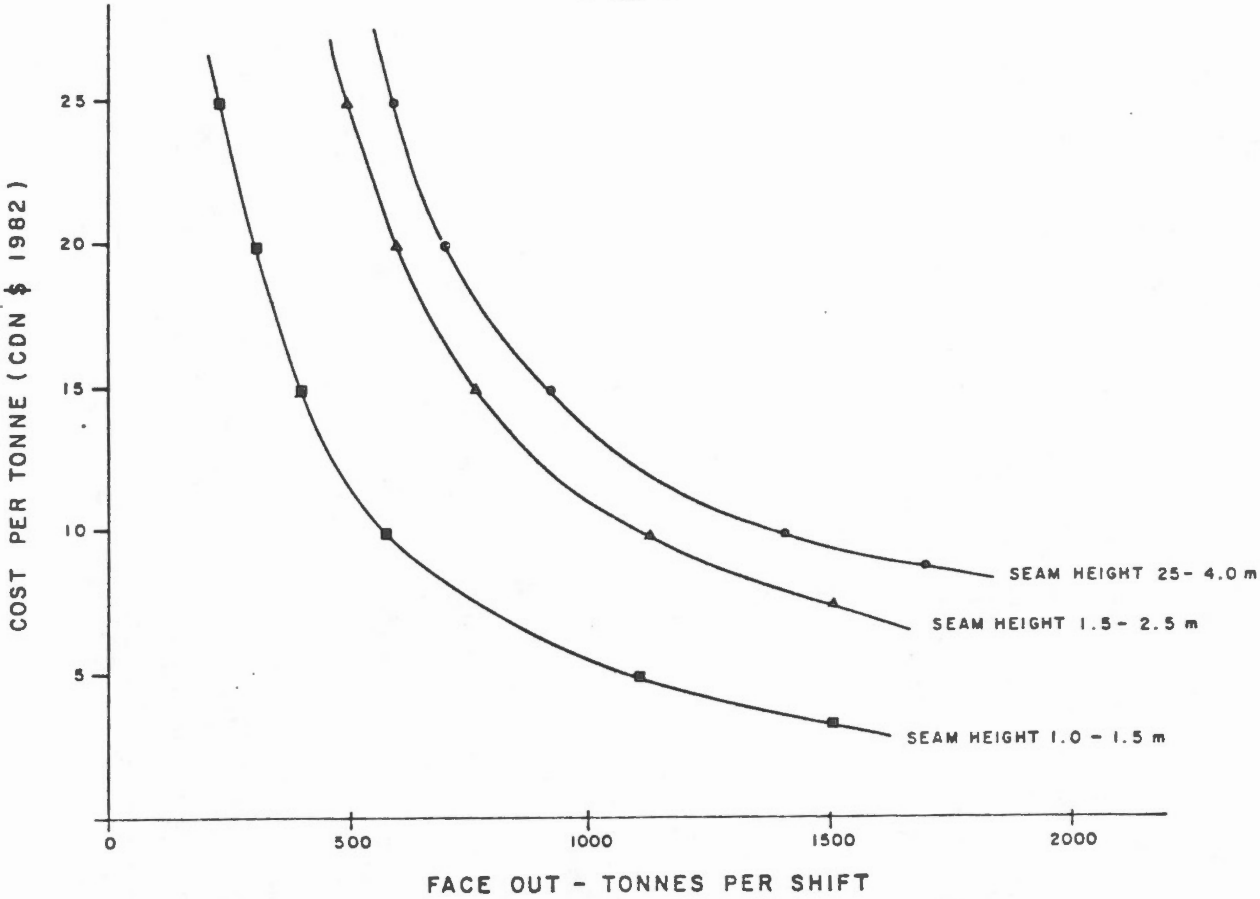


FIGURE - 7a : CAPITAL EQUIPMENT COST PER TONNE vs. OUTPUT AND SEAM HEIGHT

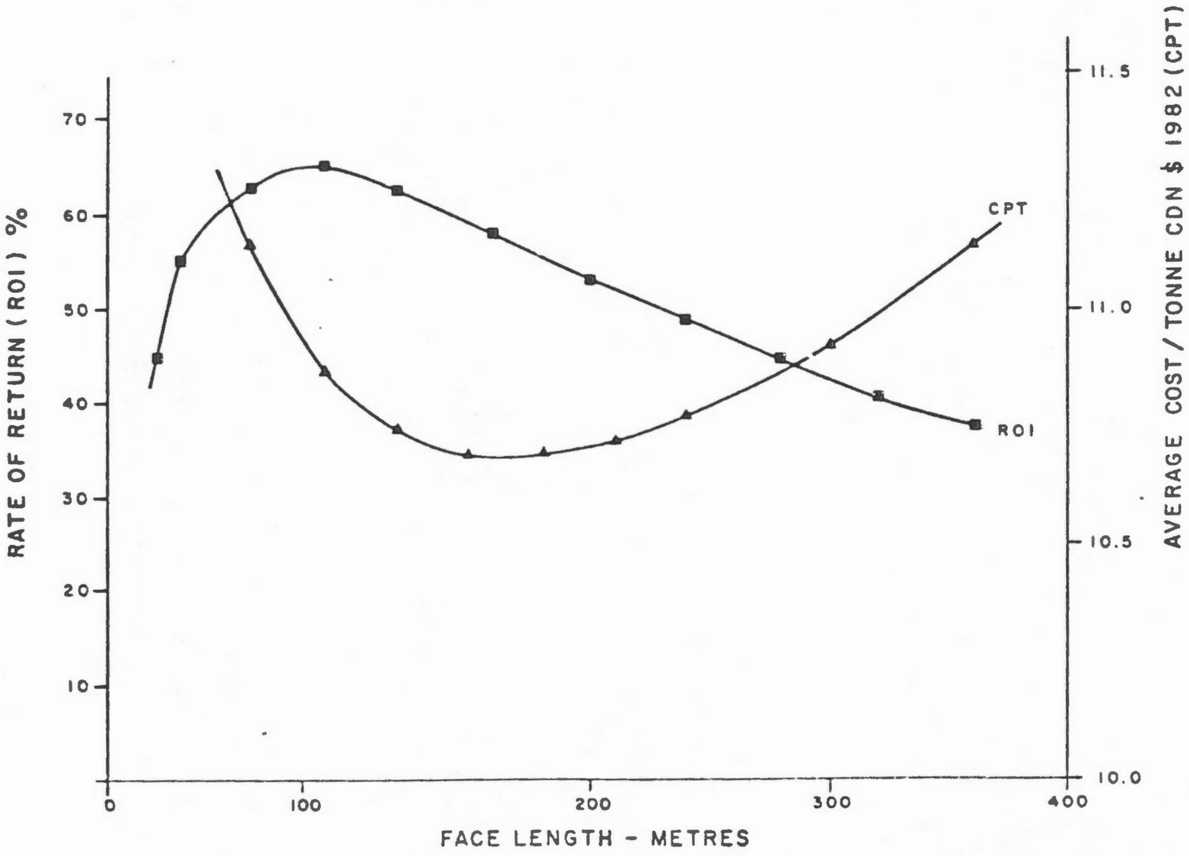


FIGURE - 7b : COST PER TONNE AND RETURN ON INVESTMENT vs. FACE LENGTH

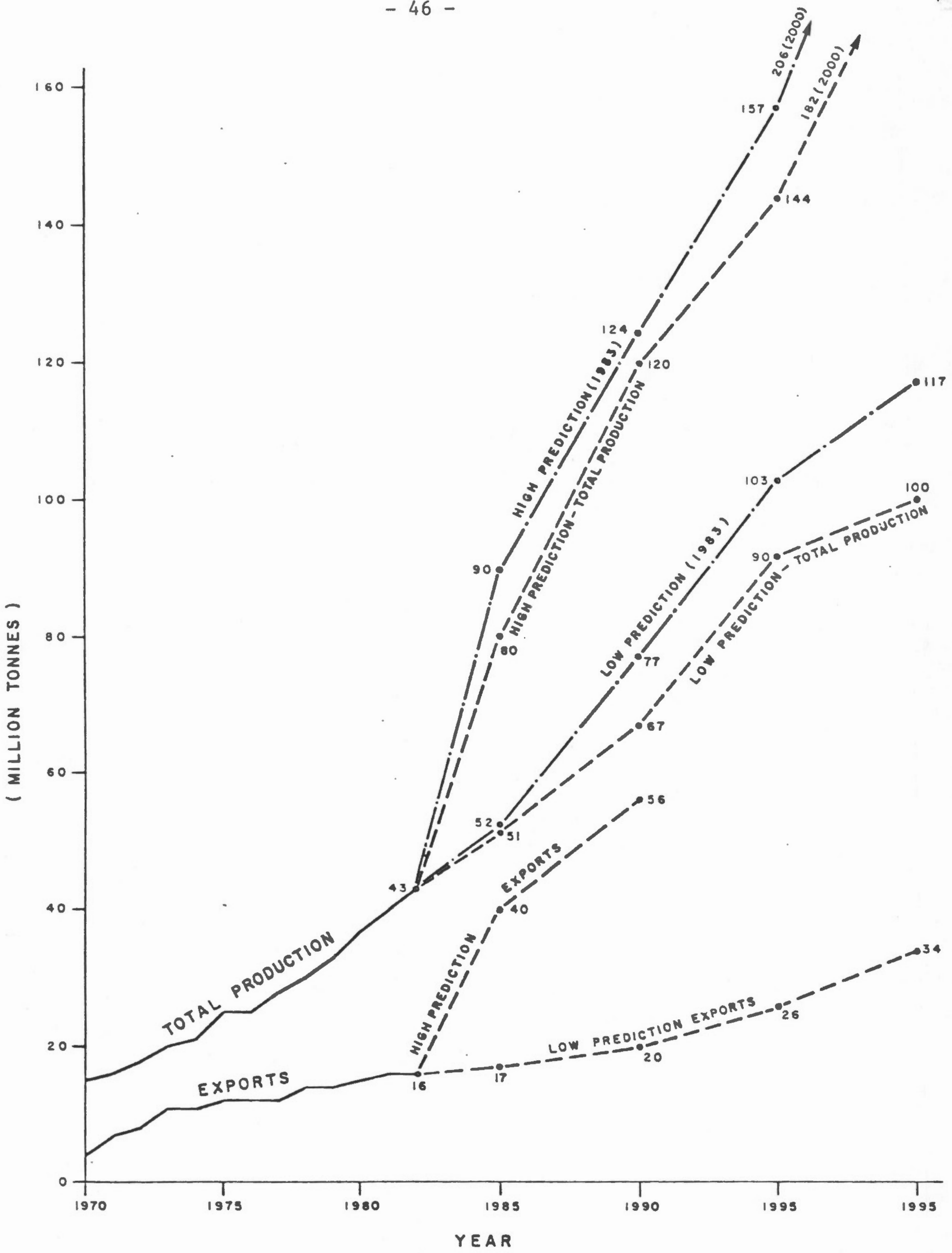
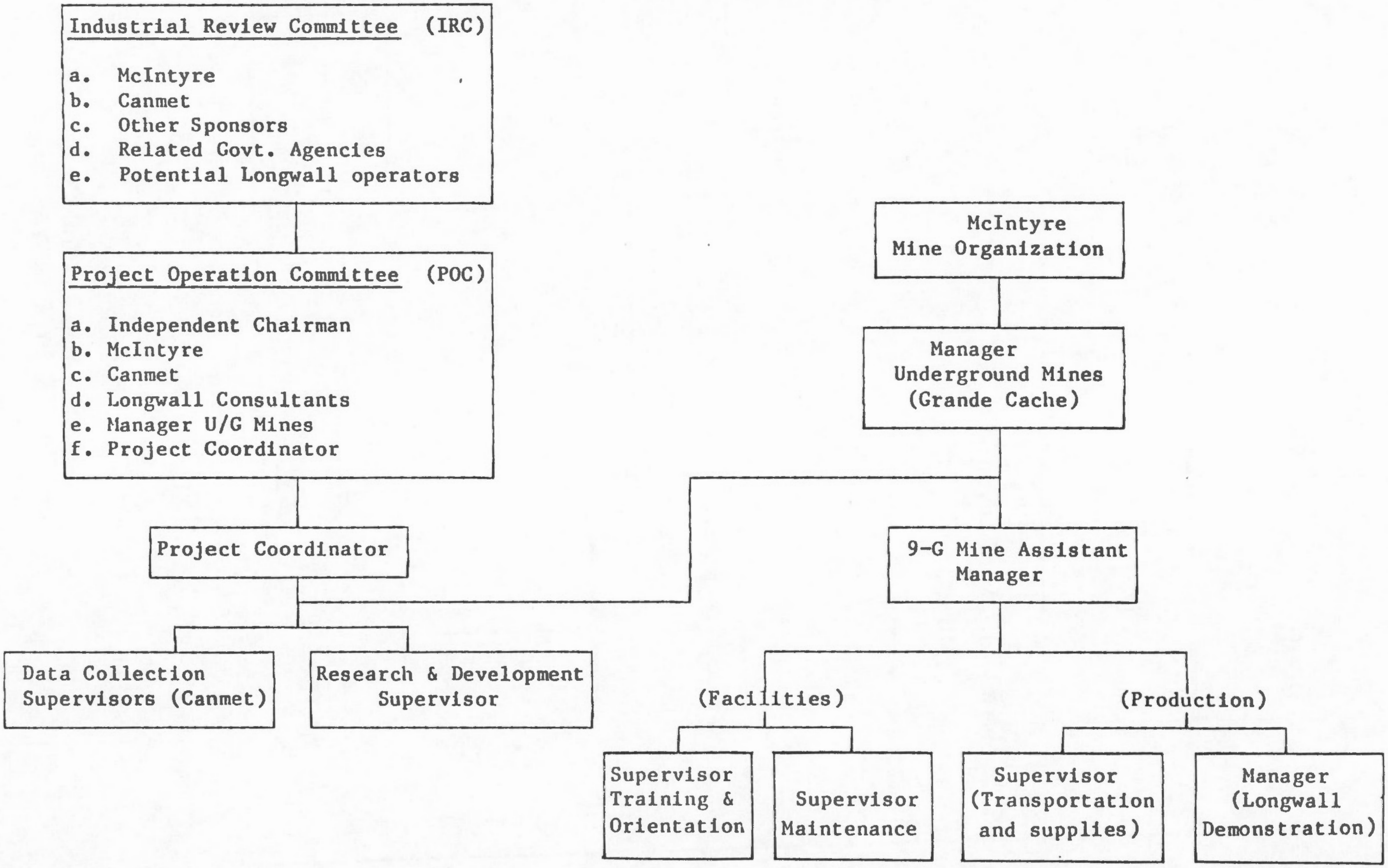


FIGURE - 8 : FUTURE PROSPECTS FOR CANADIAN COAL (CIRCA 1980)

SOURCES: 1. WORLD COAL STUDY (1980)
2. COAL ASSOCIATION OF CANADA (1981)
3. DEPT. OF ENERGY, MINES & RESOURCES (1980)

FIGURE 9
PROPOSED PROJECT CONTROL ORGANIZATION
(M^{C}INTYRE MINES DEMONSTRATION)



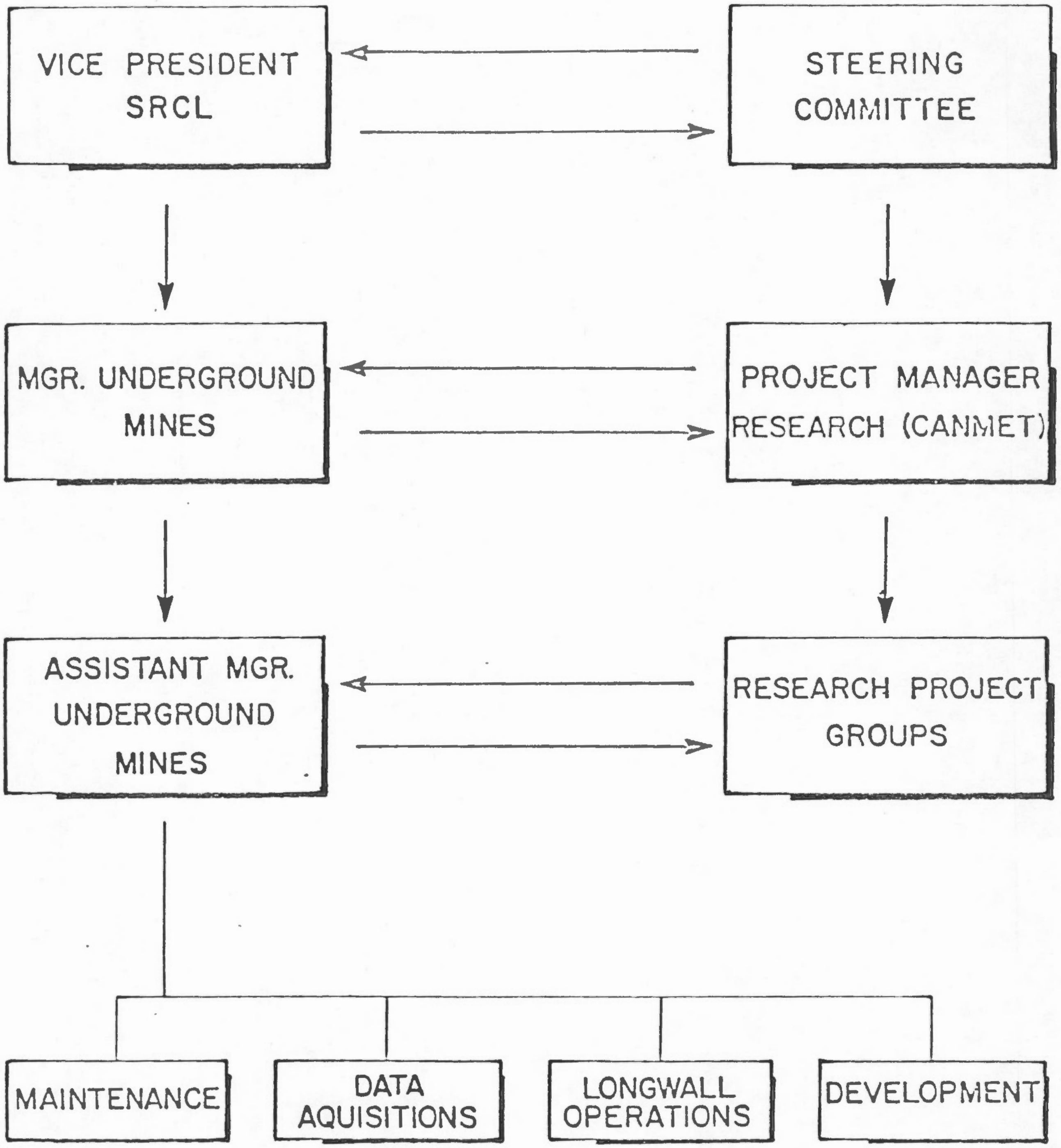


FIGURE 10
DEMONSTRATION ORGANIZATION
PROPOSED BY McINTYRE MINES