



Energy, Mines and  
Resources Canada

Énergie, Mines et  
Ressources Canada

**CANADA CENTRE FOR MINERAL AND ENERGY TECHNOLOGY  
(Former Mines Branch)**

**DIVISIONAL REPORT MRL 75-18(LS) RAPPORT DIVISIONNAIRE**

**BIBLIOGRAPHY OF HYDRAULIC  
COAL MINING**

by

A. L. Job

March 1975

MRL 75-18(LS)

01-7900361

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## ABSTRACT

This report lists a total of 213 references, many of which are annotated. The objective of the Report is to provide a ready reference to technical articles concerned with methods, equipment and related research in the underground hydraulic mining of coal. The coal may be broken by monitors or by small-diameter high-pressure jets. Some information concerning underground hydraulic transport of coal and hydraulic lifting (hydro-lifts) is included.

The appendix contains a very brief review of hydraulic coal mining and research in the U. S. S. R. and elsewhere, and a list of operating and projected hydraulic mines in Canada.

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\* Mining Engineer, Department of Energy, Mines and Resources, Ottawa.

Key Words: hydraulic coal mining, underground mining, research, bibliographies, Canada, U. S. S. R.

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## INTRODUCTION

### Arrangement of Bibliography

The bibliography is divided into the following sections: -

- 1) General
- 2) Canadian Translations
- 3) USBM Publications
- 4) Literature Surveys, Bibliographies and Abstracts
- 5) Conferences and Symposiums

While the bibliography is concerned mainly with the hydraulic mining of coal, there are included some references to hydraulic coal transport in sections 3), 4) and 5). In order to reduce the volume of material referenced, the following criteria have, in general, been adhered to:

- no information on hydraulic coal mining prior to 1959 to be included.
- no information on hydraulic pipeline - transport of coal prior to 1963 to be included.

For information prior to these dates, reference should be made to the section 'Literature Surveys, Bibliographies and Abstracts'. One exception is that all Canadian translations concerning hydraulic mining have been included regardless of the date since they are not generally listed elsewhere. Many articles of a general or entirely theoretical nature contain matter of some interest, however, due to the number and the difficulty in deciding which are of more than marginal interest, these have in general, been omitted. The Symposia and Conferences listed are usually more concerned with hydraulic transport than hydraulic mining, however, papers on jet-cutting are of interest and applicable to coal mining. A number of papers on 'hydro-lifts' are referenced as these are used in conjunction with hydraulic coal mining. All USBM publications are listed separately for convenience.

Soviet Literature

There are many technical articles on hydraulic coal mining from Soviet sources not listed in this bibliography, (Ugol, Ugol Ukrainy, Gorny Zhurnal (Izvuz), and the Scientific Reports of the Skochinski Institute). It is difficult to assess the value of these unless one is familiar with the Russian language. In a few cases translations are available. Books listed in the section Bibliography-General are by Pokrovskaya, 1972 (95), Smoldyrev, 1962 (112) and Vorobjev, 1966 (124). The latter is available in the English language. Books translated or partly translated are by Ignatieff, 1957 (154), Karachentsev, 1963 (158), Okhrimenko, 1973 (167) and Smoldyrev, 1957 (173); these are listed in the section, Canadian Translations. A soviet bibliography of hydraulic transport is listed at (205).

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Includes papers on hydraulic mining

"Transportation Research Forum", Annual Meetings:-

American (15th) San Francisco, October 1974  
Canadian (10th) Quebec City, May 1974  
Canadian (9th) Calgary, April 1973  
Canadian (8th) Halifax, May 1972  
Proc are published jointly (U.S. and Canadian)

"International Symposium on Transport and Handling of Minerals"

1st Vancouver, B. C., Oct 20-23, 1971 (Proc 25 papers, pub 1972)  
2nd Rotterdam, Holland, Oct 1-5, 1973 (Proc 22 papers, pub 1974)

"International Symposium on Jet-Cutting Technology"

1st Un of Warwick, U.K., Apr 5-7, 1972  
2nd Un of Cambridge, U.K., Apr 2-4 1974

"Symposium on Transportation", Sydney Branch of Australasian I. M. M.,  
Sydney, October 11-12, 1973

"Colloquium on Transport", London Nov-Dec, 1973. Institute of Mng  
Engrs, U.K. (10 papers)

International Conference "Hoisting men and materials", South African  
Inst of Mech Engineers, Marshalltown, October 17-22, 1973

"Symposium on Modern Developments in the Transportation Solids",  
sponsored by the South African Inst of Mech Engineers,  
Johannesburg, Box 5907, Johannesburg, S.Afr., November  
19-21, 1969.

See S Afr Mech Engr, Mar 1970, pp 51-143, 15 papers

"Colloquium: Mines Transport Symposium", London, Sept 24, 1971.  
London Br of Mng Electrical and Mech Engrs (see Mng Jr,  
May 28, 1971, pg 429)

## APPENDIX NO. 1

Hydraulic coal mining

The Soviet Union has developed underground hydraulic coal mining to a greater degree than any other country. In 1972 (latest available figures) the USSR mined 10.3 million tons of raw coal by hydraulic methods or 1½% of her total production. This came from 9 hydraulic mines and 5 hydraulic sections of conventional mines.\* The Ministry of Coal Industry has 1700 persons engaged in hydraulic mining research and development.

The Soviet Union have developed and/or tried many methods of hydraulic mining. Perhaps the best modern source of information is the book by Nikonov et al dated 1973 (166). There is, however, no known full translation of this extensive work. Other Soviet books of interest are those by Vorobjev and Deshmukh (124), Karachentsev et al (158), Okhrimenko and Kuprin (167), Smoldyrev (173), and Ignatieff and Ivanov (154). The reference Maurer (165) is also of interest.

As an example of Soviet hydraulic mining, the Yubileinaya Mine may be mentioned. This was visited by the Canadian Study Group in 1972 (25). This mine is one of four hydraulic mines operated by a Kombinat in the Kuznetsk Basin (Eastern Region of the USSR). The section visited reached a depth of some 200 metres; seams averaged about 1.8 m thick and inclination was 8° to 15°. A pillar retreat system with caving is used. Development headings are driven by a mechanical combine and pillars extracted by hydro-monitors working at pressures of 850-1750 psi. 1200 tons per day are won from the section noted. Production of the whole mine is 10,000 tpd. and 1,100 persons are employed underground.

Japan has a well developed technology in hydraulic coal mining but the tonnage mined is not known. The Balmer coal mine of Kaiser Resources

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\* Mining Congress Journal, Oct 74, 'Soviet coal through 1980'

Ltd. in British Columbia, Canada, is using Japanese assistance and techniques to develop their experimental hydraulic mine (43, 44, 140). This mine is believed to be producing at the rate of 800,000 tons raw coal per annum (equivalent to 500,000 tons clean coal). An interesting development has been the signing of an agreement in 1974 between v/o Licensintorg on behalf of the Soviet Ministry of the Coal Industry, Mitsui Mining Co. Ltd. (Japan) and Kaiser Resources Ltd. for combining and marketing hydraulic coal mining technology.

Poland, Czechoslovakia, France and some other European countries have some experience of hydraulic coal mining. A hydraulic mine in the People's Republic of China was set up with Polish aid (22, 75, 132, 175). The USBM (U.S.A.) carried out quite extensive underground tests from 1961 to 1969 but no commercial hydraulic operations have been established other than the gilsonite mining operation in Utah. (133, 183, 184, 186, 188, 192, 193, 195) The U.K. carried out underground tests in 1959 and 1960 but here again no commercial operations have been established (52, 127). West Germany have had very successful results from their experimental (full scale) hydraulic mine Carl Funke (39, 46, 97, 103, 152). New Zealand has a long history of small-scale hydraulic operations for winning coal (104).

The earliest known operation in Canada was at the Vicary Creek Colliery, Alberta, of Coleman Collieries Ltd., during 1962 (27, 137). The seam here dips at  $30^{\circ}$  and the method used was to drill a series of long six-inch holes in the seam in the direction of the dip. After completion of a hole and break-through into the under-cutting room, the drill bit was replaced by a high-pressure jet-cutting head (2800 psi) and mining commenced as the drill rod was slowly withdrawn. The system appeared to have had a successful trial but it is believed that there was difficulty in maintaining the initial bore-hole in the seam. West Germany has subsequently carried out successful experimental in-seam drilling in connection with somewhat similar mining methods.

Present operations at Balmer use a different system. (43, 44, 99, 137) Here hydraulic monitors at 2,000 psi are used in a retreat system, the broken coal being carried out of the mine in metal flumes. The seam dips 30° to 60° and averages 16-17 metres in thickness. Recovery is 60-70% of coal in each panel mined.

The system adopted at the Balmer Mine will probably be used in a new mine to be developed by Fording Coal Ltd. at Elkford, B. C. Manalta Coal plan to use a system somewhat similar to that used at Vicary Creek, Alberta.

A number of references to hydro-hoists are included (18, 72, 73, 89, 90, 109, 117, 118, 142). These systems have considerable promise in the hoisting of mineral ores and coal and in conjunction with hydraulic mining. A system first developed in Australia, the Hydro-lift feeder, is now being further developed in S. Africa. The Japanese have a successful hydro-hoist (Hitachi-hydro-hoist) operating at Yoshima Mine and Sunagawa Colliery. Probably the most extensive survey of hydro-lifts is that by Laubscher (73).

#### Canadian Research

The National Research Council of Canada have carried out research into high-pressure jets (up to 45,000 p. s. i.) for rock cutting. Their present efforts are concentrated on a slot-cutting machine working at pressures up to 20,000 psi.



## APPENDIX NO. 2

Hydraulic Coal Mining Research in the U. S. S. R.

The main institute is known as VNIIGidrougol' situated in the Kuznetsk Basin area. T. S. Cochrane (25) describes this Research Institute as follows:-

The activities of the Institute are geared to provide basic data and guidance for hydraulic mining. This Institute co-ordinates the work of a second hydraulic institute in the Ukraine. The main areas of study include hydraulic cutting, hydraulic transport, hydrodynamics of rock/coal/water mixtures, erosion and corrosion resistance and hydraulic mine design. Points of interest were:

- hydromechanical development machine using 140 atm monitor in conjunction with mechanical picks to drive in rock and coal;
- hydraulic monitors with 22 mm nozzles and pressure of 120 atm to mine shortwall faces on retreat;
- the remote control monitor mounted on crawlers to increase the width of pillar extracted and increase the recovery of coal by reducing the size of barrier pillars between extraction faces;
- the development of mine layouts to extract coal of varying thickness, inclination and hardness using field development and induced ground pressures to condition coal and increase workability;
- the development of an automatic control device which responds to changes in solid content in rise pipe and automatically adjusts the suction pipe located in hydraulic shaft haulage.

The A. A. Skochinsky Institute of Mining, Moscow, carries out research into all aspects of mining. Research concerned with hydraulic coal mining is described by Cochrane as follows:

The design of hydro-mechanical heading equipment. These units

are required for rapid development necessary in retreat or 'blocking out' systems. The units presently on the drawing board or in the prototype stage combine high pressure water jets and mechanical cutting action for breaking purposes. The advantages are in the high power/weight ratio of the compact units allowing greater flexibility, reduced cross-sections, and apparently greater potential for remote control. The water jet reduces gas and dust at source, a particular advantage, considering current stringent health and safety requirements. The hydro breaking also keeps pace with recent developments in level and vertical hydraulic transport and the trend towards a package hydraulic system.

Other Soviet research centres are:

- (1) The Ukrainian Research Institute of Hydraulic Coal Mining (UkrNIIGidrougol')
- (2) Donets Research Institute for Coal (DonUGI).

## APPENDIX NO. 3

## CANADIAN HYDRAULIC COAL MINING OPERATIONS - PRESENT AND PROPOSED

Company	Mine	Situation	Remarks
Kaiser Resources Ltd.	South Balmer Mine	Sparwood, B. C.	Hydraulic monitor operation. Operating at rate of about 3/4 million tons of raw coal per annum (15% of company's total production)
Kaiser Resources Ltd. Mitsui Mining Co. Mitsubishi Corp.	Hosmer-Wheeler Deposit	Near Sparwood, B. C.	Feasibility study being completed. Start 1978 or 1979 at 1 1/2 - 2 m. t. p. a.
Denison Mines Ltd. Mitsui Mining Co. Tokyo Boeki Co.	Babcock Deposit (Quintette area)	75 mi. S. of Chetwynd, B. C.	Development schedule to be discussed. Proposed mining rate 3, 000, 000 t. p. a. of which 60% by hydraulic methods.
Fording Coal Ltd. (Cominco Ltd. and C. P. Investments)	Eagle Mt. No. 14 Seam	38 mi. N. of Sparwood, near Elkford, B. C.	Considering use of Kaiser System. U/G testing of system required. Production possible in 3-4 years time.
Manalta Coal Ltd. (division of Mannix Co. Limited)	Gregg River	3 miles West of Luscar, Alberta	Considering use of chambering method. Awaiting Provincial development permit before further development.
Bralorne Resources	Savanna Creek	North of Coleman, S. W. Alberta	Two steeply dipping seams mineable by hydraulic methods. Exploration and assessment proceeding.

## APPENDIX NO. 4

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