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Bureau of Mines

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**LIST OF BUREAU OF MINES
PUBLICATIONS AND ARTICLES
January 1 to December 31, 1983
With Subject and Author Index**

Compiled by Staff, Branch of Editorial Services



UNITED STATES DEPARTMENT OF THE INTERIOR

William P. Clark, Secretary

BUREAU OF MINES

Robert C. Horton, Director

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As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

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U.S. Bureau of Mines

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LIST OF BUREAU OF MINES PUBLICATIONS AND ARTICLES

January 1 to December 31, 1983

With Subject and Author Index

Compiled by Staff, Branch of Editorial Services

INTRODUCTION

The Bureau of Mines was established in the public interest to conduct inquiries and scientific and technologic investigations concerning mining and the preparation, treatment, and utilization of mining substances; to promote health and safety in the mineral industries; to conserve material resources and prevent their waste; to further economic development; to increase efficiency in the mining, metallurgical, quarrying, and other mineral industries; and to inquire into the economic conditions affecting those industries. The organic act of the Bureau, as amended by Congress and approved February 25, 1913, made it the province and duty of the Bureau to "disseminate information concerning these subjects in such manner as will best carry out the purposes of this Act."

In accordance with this directive, the Bureau reports the findings of its research and investigations in its own series of publications and also in articles that appear in scientific, technical, and trade journals; in proceedings of conventions and seminars; in reference books; and in other non-Bureau publications. The number of these reports, the wide range of subjects they cover, and the variety of mediums in which they appear make the kind of list and index presented in

this special publication both necessary and valuable.

This issue of the Bureau of Mines List of Publications and Articles describes reports and articles published during the period January 1 to December 31, 1983. This publication supplements the 50-year list of Bureau publications issued from July 1, 1910, to January 1, 1960;¹ the 50-year list of articles by Bureau authors published outside the Bureau from July 1, 1910, to January 1, 1960;² the 5-year lists of publications and articles, from January 1, 1960, to December 31, 1964,³ from January 1, 1965, to December 31, 1969,⁴ from January 1, 1970, to December 31, 1974,⁵ and from January 1, 1975, to December 31, 1979;⁶ and the annual lists of publications and articles from January 1 to December 31, 1980,⁷ from January 1 to December 31, 1981,⁸ and from January 1 to December 31, 1982.⁹

¹Available from National Technical Information Service (NTIS), 5285 Port Royal Rd., Springfield, VA 22161, PB 295 062/AS.

²Available from NTIS, PB 295 432/AS.

³Available from NTIS, PB 295 481/AS.

⁴Available from NTIS, PB 198 112/AS.

⁵Available from NTIS, PB 252 843/AS.

⁶Available from the Superintendent of Documents, U.S. Government Printing Office (GPO), Washington, DC 20402. GPO Stock No. 024-004-02079-2. \$12.

⁷Available from GPO. GPO Stock No. 024-004-02096-2. \$6.

⁸Available from GPO. GPO Stock No. 024-004-02104-7. \$6.50.

⁹Available from GPO. GPO Stock No. 024-004-02121-7. \$3.50.

BUREAU PUBLICATIONS

Some Bureau of Mines publications, including most Bulletins and the Minerals Yearbook, are sales publications; other series contain both free and sales publications. Because the price of sales publications varies, the price is indicated in the individual listing of any publication for which a charge is made.

Sales publications of the Bureau of Mines must be obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402, to whom orders should be sent directly. Sales publication purchases may be made by check or money order payable to the Superintendent of Documents, charged to a deposit account at the U.S. Government Printing Office, or charged to a valid VISA or MasterCard account. Payment for orders going to foreign countries should be made by International Postal Money Order, by draft on a U.S. or Canadian bank (in U.S. dollars), or by UNESCO Coupons. Orders received with postage stamps, International Response Coupons, or foreign money are not acceptable and will be returned unprocessed. No charge is made for postage on publications mailed within the United States or its possessions. There is a special handling charge on orders mailed to other countries; the charge is one-fourth of the current selling price of the publication(s) ordered. There is a minimum charge of \$1 for each mail order.

Free publications of the Bureau of Mines may be obtained from the Section of Publications, Bureau of Mines, U.S. Department of the Interior, 4800 Forbes Avenue, Pittsburgh, PA 15213. Because of the limited editions, only 1 copy of any publication can be sent to the person applying and a maximum of 10 titles to any 1 applicant.

The following types or series of publications are issued by the Bureau of Mines.

Bulletins report the results of broad and significant projects or programs of scientific, historical, or economic research, or other investigations, including comprehensive and important mineral resource studies and compilations. Bulletins are usually prepared after all laboratory and field work has been completed, but they sometimes report a major phase of a larger or continuing investigation or research study. Bulletins rarely represent the first public report on the subject. As a rule, Bulletins encompass published work together with essential unpublished data and details.

Mineral Facts and Problems, issued every 5 years, is the Bureau's only periodic Bulletin. It contains comprehensive information on all important metals and minerals. Each commodity chapter covers industry patterns, technology, reserves, supply-demand relationships, consumption patterns, economic factors, environmental considerations, possible advances in technology, alternative future mineral supply-demand relationships, and future uses of commodities. Chapters are issued separately as preprints or reprints. Updates, issued when necessary within the 5-year cycle, appear as *Mineral Commodity Profiles*.

Handbooks are instruction or information manuals designed to improve efficiency in mineral industries or to promote the wise use of mineral resources.

Based on research and the practical experience of Bureau personnel, Handbooks cover a wide range of subjects.

Reports of Investigations present the results of process research and investigations conducted by the Bureau at its research centers or laboratories, or in mines, quarries, smelters, plants, and other non-Bureau properties. Research conducted under contract to the Bureau that is deemed worthy of publication by the Bureau can be published in the Reports of Investigation series. Reports of Investigations differ from Bulletins in that they describe the principal features and results of individual experiments (single or multiple), minor research projects, or a significant coordinated phase of a major project or program.

Information Circulars differ from Reports of Investigations in that they are concerned primarily with Bureau economic reviews and analyses and projects that are not process research by the Bureau. Information Circulars cover surveys of mineral resources and related mining and operating activities, guides to marketing of mineral commodities, compilations of historical or statistical and economic data on minerals, summaries of scientific and technical meetings and symposia, bibliographies, descriptions of new instrumentation and techniques, and descriptions of new industrial mining methods and metallurgical processes (as distinguished from those developed by the Bureau). Work done under contract to the Bureau that is deemed worthy of publication by the Bureau can be published in the Information Circular series.

Technical Progress Reports present highly significant and newsworthy developments in Bureau of Mines programs and are intended for use in conveying information that, to be of maximum value, must be published in a matter of days. Technical Progress Reports are expanded factsheets giving the technical background and details necessary to supplement a press release that reports important progress in an area of Bureau activity meriting widespread public interest. A more comprehensive treatment of the subject may be published later as a Report of Investigations.

Special Publications include the annual List of Bureau of Mines Publications and Articles and popular-type pamphlets prepared for the general public and distributed in response to requests for information on specific subjects. Special publications also include certain long and detailed publications that do not belong in any of the other series.

Mineral Perspectives are issued to inform the Bureau's audience of developments in the mineral industries and markets of a foreign country or region of the world.

Technology News is a simple factsheet discussing new technologic developments from Bureau of Mines research programs that are of interest to the minerals industry. It is issued as the need arises. For a free subscription to Technology News, write to Technology Transfer Group, Bureau of Mines, 2401 E Street, NW., Washington, DC 20241.

Mineral Issues series comprises reports that identi-

fy and evaluate mineral policy issues to assist Government and private sector analysts and decision-makers. Mineral Issues present mineral information in an analytically convenient form for the support of policy formulation and analysis; assess options to achieve mineral-related policy goals and provide an assessment of their economic, social, and environmental effects; examine specific issues of mineral economics using an accepted economics or operations research methodology; and/or assess the impact of Federal and State mineral-related policies.

Minerals Yearbooks summarize annually, on a calendar-year basis, the significant economic and technologic developments in the mineral industries. Three separate volumes are issued each year—Volume I, Metals and Minerals; Volume II, Area Reports: Domestic; and Volume III, Area Reports: International. Volume I presents, by mineral commodity, the salient statistics on production, trade, consumption, and other pertinent data. Volume II reviews the U.S. mineral industry by State and island possessions. Volume III presents the latest available mineral statistics for more than 150 countries and areas together with a review of the role of minerals in the economies of these nations. Chapters in these volumes are issued separately as preprints before the bound volumes are available.

Mineral Industry Surveys contain timely statistical and economic data on minerals. The surveys are designed to keep Government agencies and the public, particularly the mineral industry and business community, regularly informed of trends in the production, distribution, inventories, and consumption of minerals. Frequency of issue depends on the need for current data. Most of the reports

are issued monthly, quarterly, or annually. Preliminary annual data on commodities are published as soon as possible after the close of each calendar year and comprise statistics that are later printed in permanent form in the Minerals Yearbook. Preliminary annual area reports also contain data on mineral production by State, and final figures are published in Volume II of the Minerals Yearbook.

Mineral Commodity Summaries, an up-to-date summary of about 85 nonfuel mineral commodities, is the earliest Government publication to furnish estimates covering the previous year's nonfuel mineral industry data. It contains information on the domestic industry structure, Government programs, tariffs, and 5-year salient statistics.

Research 83, the 1983 edition of the Bureau's research annual, covers significant developments in Bureau programs. Each project appears as a profile accompanied by the names of the principal investigators or technical project officers, who may be consulted if further information is desired. Research 83 also includes a list of principal officials, a location map of field facilities, and a selected bibliography of publications and patents issued on Bureau developments during the past 3 years.

Minerals & Materials—A Bimonthly Survey provides timely information on selected commodities. Data and analyses are presented that are germane to policy issues of current interest. Brief narratives are supplemented by statistical graphs and tables. An economic analysis of the status of the mineral industry and articles focusing on major mineral issues are presented in each issue.

Computer tapes and printouts are occasionally available containing mineral data.

LISTS OF BUREAU OF MINES PUBLICATIONS, JOURNAL ARTICLES, AND MOTION PICTURES

Monthly List of New Publications—Bureau of Mines gives titles and abstracts of publications, open file reports, journal articles by Bureau authors, and reports placed in the National Technical Information Service (NTIS). The list also shows where the reports can be obtained or inspected, and indicates the cost of the publication if it is for sale by the Superintendent of Documents, U.S. Government Printing Office, or by NTIS.

Annual and 5-Year Lists of Bureau of Mines Publications and Journal Articles. The annual list includes titles and abstracts of most reports, along with subject and author indexes. Every 5 years, the preceding four annual listings are combined with the fifth-year listing into a 5-year list, complete with information on the various series, depository libraries, open file reports, outside publications, patents, and reprints, along with subject and author indexes. The annual and 5-year lists are sales publi-

cations; for instructions on ordering previous editions, see the footnotes on page 1 of this publication.

Bureau of Mines 1983-1984 Films, the latest edition of the Bureau film catalog, lists educational motion picture films made in cooperation with industrial firms and organizations. Most of the films depict mining and metallurgical operations and related manufacturing processes. Some show where minerals are found and how they are extracted from the earth, refined or manufactured into useful everyday products, and utilized. Others deal with mineral and other natural resources in a comprehensive manner, emphasizing the importance of these resources in the growth and development of several States. Single copies of the film catalog are available from the Office of Technical Information, Bureau of Mines, 2401 E Street, NW., Washington, DC 20241.

ASSOCIATED DOCUMENTS

Although the material in the categories that follow is not published by the Bureau of Mines, it

is listed and indexed in this publication as a service to those who may be interested.

Cooperative Publications result from investigations conducted cooperatively by the Bureau of Mines and another Government or outside organization. Although usually written either wholly or in part by Bureau personnel, they are published by the other organization. Cooperative publications include monographs and joint reports.

Open File Reports are unpublished Bureau of Mines manuscripts, reports prepared for the Bureau under contracts, or material not in manuscript form, which the Bureau makes available for consultation at Bureau facilities, in the National Library of Natural Resources at the U.S. Department of the Interior, and/or for sale through the National Technical Information Service.

Mineral Land Assessments, a special open file report series, presents results of mineral investigations of areas studied by the Bureau of Mines. The results of these mineral investigations are to be

incorporated in joint reports with the U.S. Geological Survey to provide information essential for determining the suitability of land for inclusion in the National Wilderness Preservation System.

Outside Publications are journal articles, papers in proceedings and transactions of symposia and society meetings, and other non-Bureau publications published by technical and trade journals, scientific organizations, and publishing houses.

Patents issued to the Bureau during the calendar year are listed, with instructions on how to apply for permission to use such patents.

Reprints of Bureau of Mines publications that have been made available for purchase from the National Technical Information Service, U.S. Department of Commerce, are listed in the section "Reports Available From the National Technical Information Service."

COOPERATIVE PUBLICATIONS

WITH THE STATE OF FLORIDA DEPARTMENT OF NATURAL RESOURCES BUREAU OF GEOLOGY

FBG 1-83. The Hawthorn Formation of Northeastern Florida.

Part I—The Geology of the Hawthorn Formation of Northeastern Florida, by Thomas M. Scott. **Part II—Characterization and Beneficiation of the Northeastern Florida Phosphate-Bearing Hawthorn Formation**, by B. E. Davis, G. V. Sullivan, and T. O. Llewellyn. Fla. Bureau Geol. RI 94. 1983. 90 pp.

WITH THE GEOLOGICAL SURVEY U.S. DEPARTMENT OF THE INTERIOR

The Wilderness Act (Public Law 88-577, September 3, 1964) and the Conference Report on Senate Bill 4, 88th Congress, direct the Geological Survey and the Bureau of Mines to make mineral surveys of wilderness and primitive areas. Areas officially designated as "wilderness," "wild," or "canoe" when the act was passed were incorporated into the National Wilderness Preservation System. Areas classified as "primitive" were not included in the Wilderness System, but the act provided that each area should be studied for incorporation into the Wilderness System. The act also directs the Secretary of the Interior to review roadless areas of 5,000 contiguous acres or more and every roadless island within the national wildlife refuges and game ranges under the Secretary's jurisdiction, and to report the suitability or nonsuitability of each area or island for preservation as a wilderness. The mineral surveys of the primitive areas, wildlife refuges, and game ranges are one aspect of the suitability studies.

The following publications can be obtained from—
U.S. Geological Survey
604 South Pickett St.
Alexandria, VA 22304-4658

GS 1-83. Mineral Resources of the Cougar Lakes-Mount Aix Study Area, Yakima and Lewis Counties, Washington. **Part A. Geology of the Cougar Lakes-Mount Aix Study Area**, by G. C. Simmons, with a section on interpretation of aeromagnetic data, by W. E. Davis. **Part B. Mines, Prospects, and Mineralized Areas, and Geochemistry of the Cougar Lakes-Mount Aix Study Area**, by R. M. Van Noy, N. T. Zilka, and G. C. Simmons. 1983. 81 pp. Geol. Surv. Bull. 1504. \$2.75.

GS 2-83. Mineral Resources of the North Absaroka Wilderness Study Area, Park and Sweet Counties, Montana. **Part A. Geological and Geochemical Investigations of the North Absaroka Wilderness Study Area**, by J. E. Elliot, D. L. Gaskill, and W. H. Raymond. **Part B. Geophysical Interpretations**, by D. L. Peterson. **Part C. Economic Appraisal of the North Absaroka Wilderness Study Area**, by R. B. Stotelmeyer, F. L. Johnson, D. S. Lindsey, James Ridenour, and S. W. Schmauch. **Part D. Geothermal Resource**, by N. T. Zilka. 1983. 251 pp. Geol. Surv. Bull. 1505. \$15.

GS 3-83. Mineral Resources of the Mill Creek, Mountain Lake, and Peters Mountain Wilderness Study Areas, Craig and Giles Counties, Virginia, and Monroe County, West Virginia, by F. G. Lesure, B. B. Williams, and M. L. Dunn, Jr. With a section on oil and gas potential, by W. J. Perry, Jr. 1982. 76 pp. Geol. Surv. Bull. 1510. \$7.50.

GS 4-83. Mineral Resources of the Rock River Canyon Wilderness Study Area, Alger County, Michigan, by J. W. Whitlow, P. J. Geraci, and P. C. Mory. With a section on geophysical-data interpretation, by E. R. King. 1983. 43 pp. Geol. Surv. Bull. 1549. \$3.75.

GS 5-83. Mineral Resources of the Caney Creek Wilderness, Polk County, Arkansas, by G. E. Erickson, S. H. Patterson, M. L. Dunn, Jr., and D. K. Harrison. 1983. 42 pp. Geol. Surv. Bull. 1551. \$4.

COMPUTER TAPE

The following material is available only from the National Technical Information Service, U.S. Department of Commerce, Springfield, VA 22161. Checks or money orders should be made payable to the U.S. Department of Commerce. Do not send cash or postage stamps. Please include your ZIP code. The prices at the National Technical Information Service are subject to change; therefore, price codes are given. Contact the National Technical Information Service for a current copy of the domestic or foreign order price schedule.

CT 1-83. Modernization of the BMINES Computer Code. Vol. I: User's Guide. Vol. II: Methodology, by David E. Van Dillen, Richard W. Fellner, Robert D. Ewing, and Thomas J. R. Hughes. Sept. 23, 1981. This is a static, two- and three-dimensional, nonlinear, finite element computer program for the analysis of structural and geological systems and is designed specifically for application to the mining problems involving the simulation of excavation in construction sequences. The program is intended for practical analysis, and an effort was made to foresee difficulties in using it. The program uses the direct stiffness method of structural analysis. Degrees of freedom are defined at nodal points and element stiffnesses are assembled to form a symmetric, banded global stiffness matrix. Nodal point forces, which include external loads and internal resisting forces, are expressed in a global load vector. Incremental displacements are obtained from the global load vector and global stiffness matrix by a banded triangulation of the global stiffness matrix, reduction of the load vector, and then back substitution of the reduced load vector into the triangulated stiffness matrix. Part of the reduction operations are performed in local double

precision to reduce error propagation, and size limitations have been eliminated. The program includes the capability of prescribing initial states of stress. The output available includes both printed and plotted responses. A restart capability for the calculation phase is included so that large problems may be split into several runs. An attempt was made to lengthen the useful life of the program by making it simple to add new elements, to expand the material model descriptions, and by making the program efficient for and compatible with a wide variety of computers. The model is written in Fortran 4 and is currently operational on a CDC Cyber 176 computer. Approximately 131K words of memory are required with 3 overlays. Source tape is in ASCII character set. Character set restricts preparation to 9-track, 1/2-in tape only. Identify recording mode by specifying density only. Call NTIS Computer Products (703-487-4763) if you have any questions. Research done under contract H0282022 by Agbajian Associates. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. NOTE: NTIS lists this under the title "BMINES: Static, Three-Dimensional, Nonlinear, Finite Element Computer Program for Application to Mining Problems." Order ONLY from NTIS: PB 83-221572 (computer tape plus documentation): price code T14. Documentation only may be obtained by ordering volume I, 616 pp.: PB 83-221564; paper copy price code A99; volume II, 45 pp.: PB 83-221566; paper copy price code A03.

TECHNICAL PROGRESS REPORTS

Single copies of the Technical Progress Reports can be obtained from the Section of Publications, Bureau of Mines, U.S. Department of the Interior, 4800 Forbes Avenue, Pittsburgh, PA 15213. The Technical Progress Report series was discontinued on September 28, 1983.

TPR 120. A Microwave System for the Acid Dissolution of Metal and Mineral Samples, by S. A. Matthes, R. F. Farrell, and A. J. Mackie. 1983. 9 pp. 4 figs. This Bureau of Mines report describes a system for the dissolution of metal and mineral samples using a microwave heat source. Samples and an acid mixture are placed in sealed polycarbonate vessels. The vessel contents are heated using microwaves, digested for 2 min, and quickly cooled. After the solution is brought to a final volume, the vessel contents are heated an additional 2 min in the microwave oven. Using this method, a slag, a feldspar, and a Ni-Cu alloy were dissolved and analyzed by atomic absorption spectroscopy. Values obtained for Na, K, Cu, Ni, Si, Mg, Mn, Ca, Al, and Fe agreed with certified values and had an average relative standard deviation of 1 pct. This system results in a significant savings in time and expense over traditional methods of sample dissolution, and is ideal for preparing solutions for analysis by atomic absorption, plasma optical emission, or X-ray spectroscopy.

TPR 121. Bit Ignition Potential With Worn Carbide Tips, by Wallace W. Roepke and Bruce D. Hanson. 1983. 7 pp. 4 figs. The Bureau of Mines has a well-established health and safety research effort directed to fundamental studies of the mine cutting system. This report describes the ignition danger of using cutting bits with flat wear area on still-intact carbide inserts.

TPR 122. Cl₂-O₂ Leaching of Massive Sulfide Samples From the Southern Juan de Fuca Ridge, North Pacific Ocean, by D. L. Sawyer, Jr., G. A. Smyres, J. J. Sjoberg, and T. G. Carnahan. 1983. 8 pp. 5 figs. Aqueous Cl₂-O₂ leaching procedures developed by the Bureau of Mines to produce zinc chloride from zinc sulfide bulk concentrates were effective in extracting 99 pct of the zinc and 97 pct of the silver contained in samples of massive seafloor sulfides from the southern Juan de Fuca Ridge. Zinc sulfide (sphalerite and wurtzite) mineralization comprised 55 and 88 pct of two specimens provided by the U.S. Geological Survey for this study. Minor occurrences of galena, chalcopyrite, and other minerals in the sulfides permitted the recovery of pregnant liquors that were low in metal values other than zinc, which were successfully purified by a two-step cementation procedure using zinc dust.

MINERAL INDUSTRY SURVEYS

Mineral Industry Surveys are processed reports that contain statistical and economic data on various mineral commodities. These reports are issued at regular intervals so that information on mineral commodities may be made available quickly and in a convenient form. Most of the data contained in these reports appear in permanent form in the Bureau of Mines Minerals Yearbook. Single copies of these reports may be obtained from the Section of Publications, Bureau of Mines, U.S. Department of the Interior, 4800 Forbes Avenue, Pittsburgh, PA 15213. Mineral Industry Surveys dealing with various mineral commodities will be forwarded regularly if application stating in detail the need for certain reports is made to the Branch of Editorial Services, Bureau of Mines, U.S. Department of the Interior, 4900 La Salle Road, Avondale, MD 20782. The following Mineral Industry Surveys were being published in 1983 by the Bureau of Mines. Mineral Industry Surveys are also published annually that contain preliminary data on mineral production for each State.

MONTHLY

Aluminum Industry.
Cement.
Chromium.
Cobalt.
Copper.
Gold and Silver.
Gypsum.
Iron and Steel Scrap.
Iron Ore.
Lead Industry.
Lime.
Manganese.
Molybdenum.
Nickel.
Phosphate Rock.
Silicon.
Sodium Compounds.
Sulfur.
Tin Industry.
Tungsten.
Vanadium.
Zinc Industry.

QUARTERLY

Antimony.
Bauxite.
Bismuth.
Cadmium.
Copper Sulfate.
Fluorspar.
Magnesium.

Mercury.
Platinum-Group Metals.
Selenium.
Titanium.

ANNUALLY

Abrasive Materials.
Aluminum and Bauxite.
Antimony.
Arsenic.
Asbestos.
Barite.
Beryllium.
Bismuth.
Boron.
Bromine.
Cadmium.
Calcium and Calcium Compounds.
Cement.
Cesium and Rubidium.
Chromium.
Clays.
Cobalt.
Columbium and Tantalum.
Copper.
Corundum.
Diamond, Industrial.
Diatomite.
Feldspar.
Ferroalloys.
Fluorspar.
Gallium.
Garnet.
Gem Stones.
Gold and Silver.
Graphite.
Gypsum.
Iodine.
Iron and Steel.
Iron and Steel Scrap.
Iron and Steel Slag.
Iron Ore.
Iron Oxide Pigments.
Kyanite and Related Minerals.
Lead.
Lime.
Lithium.
Magnesium and Magnesium Compounds.
Manganese.
Mercury.
Mica.
Molybdenum.
Nickel.
Nitrogen, Fixed.
Peat.
Perlite.
Phosphate Rock.

MINERAL INDUSTRY SURVEYS

Phosphate Rock (Crop Year).
Platinum-Group Metals.
Potash.*
Potash (Crop Year).
Pumice and Pumicite.
Quartz Crystal.
Rare-Earth Elements, Yttrium, and Thorium.
Rhenium.
Salt.
Sand and Gravel.
Selenium and Tellurium.
Silicon.
Sodium Carbonate.
Sodium Compounds.

Sodium Sulfate.
Stone—Crushed.
Stone—Dimension.
Strontium.
Sulfur.
Talc and Pyrophyllite.
Tin.
Titanium.
Tungsten.
Vanadium.
Vermiculite.
Zinc.
Zirconium and Hafnium.

SPECIAL MINERAL COMMODITY PUBLICATIONS

The following publications are issued to assist producers and consumers of mineral commodities, policymakers, mineral industry experts, and the general public to keep abreast of developments in the mineral industries. The publications provide brief summaries or tabulations of significant information from various sources. Single copies of these publications may be obtained from the Section of Publications, Bureau of Mines, U.S. Department of the Interior, 4800 Forbes Avenue, Pittsburgh, PA 15213.

Minerals and Materials—A Bimonthly Survey provides timely information on selected commodities. Data and analyses are presented that are germane to policy issues of current interest. Brief narratives are supplemented by statistical graphs and tables. An economic analysis of the status of the mineral

industry and articles focusing on major mineral issues are presented in each issue. To be placed on a mailing list to receive copies of *Minerals and Materials* on a regular basis, write to U.S. Department of the Interior, Bureau of Mines, Division of Minerals Policy and Analysis, 2401 E Street NW., Washington, DC 20241.

Mineral Commodity Summaries, an annual publication, is the earliest Government publication to furnish estimates of the previous year's nonfuel mineral industry data. Most of the estimates are based on 9 months data. The 1983 edition contains information on the domestic industry structure, Government programs, tariffs, and 5-year salient statistics for 86 individual minerals and metals.

1982 MINERALS YEARBOOK

The 1982 Minerals Yearbook, published in three volumes, provides a record of performance of the Nation's mineral industries during the year and a review of world mineral production, consumption, and trade on a country-by-country basis. The complete volumes are available for the prices indicated from—

Superintendent of Documents
Government Printing Office
Washington, DC 20402

Volume I. Metals and Minerals, prepared by the staff of the Bureau of Mines. 1984. 73 ch. 961 pp. This volume of the Minerals Yearbook, covering metals and minerals, contains 73 commodity or commodity group chapters with data on approximately 90 minerals that were obtained as a result of the mineral information gathering activities of the Bureau of Mines. In addition, the volume contains a chapter on mining and quarrying trends and a

statistical summary. GPO Stock No. 024-004-02124-1. \$16.

Volume II. Area Reports: Domestic, 1982, prepared by the staff of the Bureau of Mines. 1984. 52 ch. 601 pp. This volume of the Minerals Yearbook contains chapters on the mineral industry of each of the 50 States, the U.S. island possessions in the Pacific Ocean and the Caribbean Sea, and the Commonwealth of Puerto Rico. This volume also has a statistical summary. GPO Stock No. 024-004-02132-2. \$14.

Volume III. Area Reports: International, 1982, prepared by the staff of the Bureau of Mines. 1984. 90 ch. 1239 pp. This volume of the Minerals Yearbook contains the latest available mineral data on more than 130 foreign countries and discusses the importance of minerals in the economies of these nations. A separate chapter reviews the international minerals industry in general and its relationship to the world economy. GPO Stock No. 024-004-02129-2. \$20.

MINERAL COMMODITY PROFILES

The "Mineral Commodity Profile" series presents the latest data on important strategic minerals including background information on industry structure, technology, reserves, timely economic data, and forecasts of future supply-demand relationships. These commodity-specific publications serve as updates to "Mineral Facts and Problems" and are issued in the middle years of the "Mineral Facts and Problems" 5-year cycle. Single copies can be obtained without charge by writing to the Section of Publications, Bureau of Mines, U.S. Department of the Interior, 4800 Forbes Avenue, Pittsburgh, PA 15213, or calling 412-261-4500, extension 342. The following "Mineral Commodity Profile" reports were published in 1983.

Aluminum, by Luke H. Baumgardner and Frank X. McCawley. 20 pp. 3 figs.
Chromium, by John F. Papp. 21 pp. 2 figs.
Cobalt, by William S. Kirk. 16 pp. 2 figs.

Columbium, by Larry D. Cunningham. 14 pp. 1 fig.
Copper, by W. C. Buttermann. 18 pp. 6 figs.
Fluorspar, by Lawrence Pelham. 14 pp. 1 fig.
Gold, by J. M. Lucas. 17 pp. 2 figs.
Iron Ore, by F. L. Klinger. 14 pp. 3 figs.
Iron and Steel, by Frederick J. Schottman. 16 pp. 5 figs.
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Phosphate Rock, by W. F. Stowasser. 18 pp. 6 figs.
Platinum-Group Metals, by J. Roger Loebenstein. 20 pp. 7 figs.
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Vanadium, by Peter H. Kuck. 18 pp. 2 figs.
Zinc, by James H. Jolly. 18 pp. 3 figs.

MINERAL PERSPECTIVES

The "Mineral Perspectives" series reports on the mineral resources, industries, and related infrastructure of those foreign sources (individual countries or regions of the world) that assume major importance to our Nation's mineral needs. Single copies of "Mineral Perspectives" reports can be obtained by writing to—

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MP. **Namibia**, by G. Coakley, S. Ambrosio, P. Clarke, M. Ellis, and E. Shekarchi. 1983. 57 pp. 7 figs. Namibia, the former Territory of South-West Africa, has a large and diversified mining industry,

which supplies approximately 45% of its gross domestic product and 70% of its foreign exchange earnings. It is one of the world's largest producers of gem diamonds and uranium and also produces a substantial quantity of base metals, including copper, lead, and zinc. Several of the world's largest multinational mining companies are or have been actively involved in producing minerals in Namibia. This Bureau of Mines report provides an in-depth look at the structure, production history, and resource position of Namibia's mineral industry. The study points to uranium as having the greatest potential for sustaining long-term growth in the mining sector, while diamond and base metal production appear to have peaked and may decline in the short to medium term. The report also describes the administrative and economic dependence of Namibia on the Republic of South Africa and analyzes those aspects of mineral policy, labor, and water and energy resources that will affect future development of Namibia's mineral resources.

MINERAL ISSUES

The "Minerals Issues" series addresses contemporary mineral policy issues to assist Government and private sector decisionmakers. Reports in the series present nonfuel-mineral-base information in a form convenient for the support of policy formulation and analysis; identify options to achieve mineral-related national needs and goals and provide an assessment of their political, social, and economic effects; examine specific aspects of mineral economics or operations research methodology; and/or assess the impact of Federal and State mineral-related policies.

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MI. **Taxation and the Profitability of Mineral Operations in Seven Mountain States and Wisconsin: A Hypo-**

MINERAL ISSUES

thetical Study, by Robert L. Davidoff and Ronald J. Hurdbrink. 1983. 32 pp. 12 figs. The potential profitability level of a mineral property depends on the geologic, engineering, and economic characteristics of the deposit, but may also depend to a large extent on the local tax structure. This Bureau of Mines study uses the Bureau's Mine Simulator (MINSIM) economic evaluation computer program and three hypothetical mineral properties

to examine the differential impact on profitability of the tax structures of eight mineral-producing States. Wide variations between States in calculated rates of return indicates that tax structure could in some instances be the determining factor (given identical deposits) in a decision on whether or not to develop a property. GPO Stock No. 024-004-02119-5. \$3.75.

HANDBOOKS

Handbooks are instruction or information manuals designed to improve efficiency in the mineral industries or to promote the wise use of mineral resources. Based on research and the practical experience of Bureau and contractor personnel, they give specific instructions on various subjects.

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HB 1-83. Techniques for Constructing Concrete Block Stoppings, by Robert J. Timko and Edward D. Thimons. 1983. 29 pp. 24 figs. The Bureau of Mines has evaluated several techniques that will enhance the airtightness of concrete block permanent stoppings used in mines for airflow control. These

techniques have been combined to create three distinct stopping types, each with its own utility. This handbook describes the three types of stoppings and includes illustrated step-by-step instructions for their construction.

HB 2-83. Mining Machinery Noise Control Guidelines, 1983, by Roy C. Bartholomae and Robert P. Parker. 1983. 87 pp. 42 figs. The Mine Health and Safety Act of 1977 seeks to protect miners by regulating their exposure to excessive noise in the mining environment. When a worker's exposure is found to be excessive, the utilization of existing engineering noise control measures are required to abate the noise. Over the past decade, the Bureau of Mines has undertaken a number of noise control programs aimed at establishing a technology base that can be used by industry to effect solutions to noise problems. Many of these hardware-oriented programs have provided the development and demonstration of retrofit noise control treatments for mining machinery. The purpose of this Handbook is to synthesize evolving and available noise control information and disseminate it within the mining industry.

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SP 1-83. Mineral Commodity Summaries 1983, by Staff, Bureau of Mines. 1983. 183 pp. This report is the earliest Government publication to furnish estimates covering 1982 nonfuel mineral industry data. Most of the estimates are based on 9 months data. These data sheets contain information on the domestic industry structure, Government programs, tariffs, and 5-year salient statistics for 86 individual minerals and metals. World resource data appearing in the statements have been provided by the Geological Survey.

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SP 2-83. The Domestic Supply of Critical Minerals, by the White House Staff and the Bureau of Mines. 1983. 49 pp. 38 figs. This report summarizes, primarily in graphic form, the major factors that govern the adequacy of national mineral supply. The complexity of mineral issues is well demonstrated, and the reader will gain appreciation for the international as well as the domestic aspects of some of the mineral supply and demand problems facing the United States. GPO Stock No. 024-004-02112-8. \$5.50.

SP 3-83. Bureau of Mines Research 83. A Summary of Significant Results in Mineral Technology and Economics, compiled and edited by Jerald R. Pederson. 1983. 173 pp. 93 figs. Minerals, and the adequacy of America's mineral supply, are subjects of growing national concern in the 1980's. They have been subjects of concern to the Bureau of Mines for most of this century. The Bureau's mission is to help assure an adequate and dependable flow of minerals at reasonable costs. That mission is pursued through the acquisition and analysis of minerals data on a worldwide basis, and through research to make mining and mineral processing safer, more productive, and more compatible with the effective use of all the Nation's resources. Research 83 is the 13th annual summary of significant developments in Bureau programs. It reflects both the scope of the Bureau's mission, and

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the success with which that mission is being pursued. GPO Stock No. 024-004-02123-3. \$5.50.

SP 4-83. List of Bureau of Mines Publications and Articles, January 1 to December 31, 1982. With Subject and Author Index, compiled by Staff, Branch of Editorial Services. 1983. 169 pp. This issue of the Bureau of Mines List of Publications and Articles describes reports and articles published during the period January 1 to December 31, 1982. This publication supplements the 50-year list of Bureau publications

issued from July 1, 1910, to January 1, 1960; the 50-year list of articles by Bureau authors published outside the Bureau from July 1, 1910, to January 1, 1960; the 5-year lists of publications and articles, from January 1, 1960, to December 31, 1964, from January 1, 1965, to December 31, 1969, from January 1, 1970, to December 31, 1974, and from January 1, 1975, to December 31, 1979; and the annual lists of publications and articles from January 1 to December 31, 1980, and from January 1 to December 31, 1981. GPO Stock No. 024-004-02121-7. \$3.50.

PATENTS

The following patents were granted to the Bureau of Mines during calendar year 1983. These processes, which may be used by any U.S. citizen or organization without royalty payment upon authorization by the U.S. Department of the Interior, are based on work done by Bureau scientists or under contracts with the Bureau. Application for the use of any of the patents should be made to the Branch of Procurement and Patents, Division of General Law, Office of the Solicitor, U.S. Department of the Interior, Washington, DC 20240.

P 1-83. Combined Aerosol Monitor and Calibrateable Light Ray Scattering Reference Rod. Jerry J. Klug. U.S. Pat. 4,367,950, Jan. 11, 1983.

P 2-83. Thermally Activated Metal Hydride Sensor/Actuator. Peter M. Golben. U.S. Pat. 4,377,209, Mar. 22, 1983.

P 3-83. Chromium Recovery From Superalloy Scrap by Selective Chlorine Leaching. John A. Thomas, David L. Jones, and Victor A. Ettl. U.S. Pat. 4,377,410, Mar. 22, 1983.

P 4-83. Selective Paging and Intercommunication System. William H. Schiffbauer and Richard A. Watson. U.S. Pat. 4,377,726, Mar. 22, 1983.

P 5-83. Separation of Zirconium and Uranium. David J. MacDonald and Helen G. Henry. U.S. Pat. 4,381,287, Apr. 26, 1983.

P 6-83. Removal of Suspended Solids From Water. Joseph E. Schiller and Sanaa E. Khalafalla. U.S. Pat. 4,385,998, May 31, 1983.

P 7-83. Apparatus and Method for Measuring Low Concentrations of High Molecular Weight Polymers in Solution. Jalna R. Zatzko. U.S. Pat. 4,386,518, June 7, 1983.

P 8-83. Continuous Transducer Drift Compensator. George M. Lucich and Charles A. Seitz. U.S. Pat. 4,387,438, June 7, 1983.

P 9-83. Method for Controlled Burnout of Abandoned Coal Mines and Waste Banks. Robert F. Chaiken. U.S. Pat. 4,387,655, June 14, 1983.

P 10-83. Extraction of Aluminum From Clay. William G. Gruzensky and Richard S. Olson. U.S. Pat. 4,388,280, June 14, 1983.

P 11-83. Borehole Gauge for In-Situ Measurement of Stress and Other Physical Properties. Clarence O. Babcock. U.S. Pat. 4,389,896, June 28, 1983.

P 12-83.* Modified Sulfur Cement. William C. McBee and Thomas A. Sullivan. U.S. Pat. 4,391,969, July 5, 1983.

P 13-83. Method of Hydrospealing. Martin S. Oudenhoven. U.S. Pat. 4,394,051, July 19, 1983.

P 14-83. Water Spray Cooler. Edward D. Thimons, Kenneth S. Heller, John F. McCoy III, and Austin Whillier. U.S. Pat. 4,394,142, July 19, 1983.

P 15-83. High Temperature Hydrolysis of Aluminum Sulfate Solutions. Donald E. Shanks. U.S. Pat. 4,394,368, July 19, 1983.

P 16-83. Recovery of Arsenic From Flue Dust. Brent W. Madsen, Henry Dolezal, Philip A. Bloom, and Monte B. Shirts. U.S. Pat. 4,401,632, Aug. 30, 1983.

P 17-83. Open Surface Flotation Method for Extracted Crude Oil. Dan M. Bass and Fun-Den Wang. U.S. Pat. 4,402,552, Sept. 6, 1983.

P 18-83. Thermal Decomposition of Aluminum Chloride Hexahydrate. Eugene Miller and Gerald B. McSweeney. U.S. Pat. 4,402,932, Sept. 6, 1983.

P 19-83. Readout Circuit for Linear Displacement Transducer. Michael G. Hughes, Radu R. Tenenbaum, and Al Bugay. U.S. Pat. 4,404,523, Sept. 13, 1983.

P 20-83. Pressureless Consolidation of Metallic Powders. James L. Holman, Jr., John F. McIlwain, and L. A. Neumeier. U.S. Pat. 4,407,775, Oct. 4, 1983.

P 21-83. Recovery of Metals From Grinding Sludges. James L. Holman, Jr., and Leander A. Neumeier. U.S. Pat. 4,409,020, Oct. 11, 1983.

P 22-83. Recovery of Tungsten From Brines. S. Ralph Borrowman, Paulette B. Altringer, and Parkman T. Brooks. U.S. Pat. 4,409,189, Oct. 11, 1983.

P 23-83. Recovery of Metal Values From Complex Sulfides. Gary A. Smyres and Philip R. Haskett. U.S. Pat. 4,410,496, Oct. 18, 1983.

P 24-83. Selective Recovery of Base Metals and Precious Metals From Ores. Elizabeth G. Baglin and John M. Gomes. U.S. Pat. 4,423,011, Dec. 27, 1983.

* This patent, although based on work done by Bureau of Mines personnel, is being licensed by the U.S. Department of Commerce. For details, contact National Technical Information Service, Office of Government Inventions and Patents, U.S. Department of Commerce, P.O. Box 1423, Springfield, VA 22151.

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RI 8721. Removal of Leachable Metals and Recovery of Alumina From Utility Coal Ash, by Robert C. Gabler, Jr., and Robert L. Stoll. 1983. 20 pp. 3 figs. The extraction of metals from coal ash was investigated by the Bureau of Mines in an effort to produce a more environmentally acceptable waste and offset waste disposal costs with recovered metal values. The research was conducted in two steps: determination of the parameters that affect extraction of metals from coal ash and development of extraction-recovery procedures. Data obtained indicate that the major parameter affecting the extraction of metals from coal ash is the calcium content of the ash. Other parameters such as furnace type and operating temperature had much smaller effects on metal extraction. Two procedures were studied for metal extraction: an acid leach procedure for high-calcium ashes and a lime sinter-acid leach procedure for low-calcium ashes. An alumina product was recovered that, with sufficient washing, meets Hall cell specifications. The leach residues pass the EPA EP Toxicity Test and are thus non-hazardous wastes available for a variety of uses.

RI 8740. Precision of Personal Sampling of Respirable Dust in Coal Mines, by John A. Breslin, Steven J. Page, and Robert A. Jankowski. 1983. 12 pp. 2 figs. The Bureau of Mines measured respirable dust in coal mines by means of multiple dust samplers worn by persons moving about the mines. The measurements were made primarily to evaluate the effectiveness of certain dust-control techniques; however, for this report, the data have been analyzed to determine the precision of the personal dust-sampling measurements. A total of 68 sets of measurements were available from multiple personal samplers. The measured dust masses were less than 1.0 mg because the sampling times were short. The coefficient of variation calculated from these data was 18.5 pct, compared with coefficients of variation ranging from about 10 to 30 pct, which were calculated from the most precise and extensive data available for fixed-point dust measurements made in coal mines. From this comparison, it is concluded that dust samplers worn by personnel are as precise as fixed-point samplers in measuring respirable coal

dust; the wearing of the samplers by someone moving about a mine does not contribute significantly to the variation in measurements made with these instruments.

RI 8741. Debrining of Potash-Clay Waste Slurries, by Annie G. Smelley, Bernard J. Scheiner, Margaret M. Ragin, and Jalna R. Zatko. 1983. 11 pp. 7 figs. As part of its program to develop technology that will encourage maximum utilization of the Nation's mineral resources, the Bureau of Mines conducted research on debrining potash-clay waste slurries by means of flocculation with a high-molecular-weight polymer and subsequent solid-liquid separation on a rotating trommel screen. In laboratory batch tests, potash-clay waste slurries were consolidated from initial clay contents of 8 pct to final contents of 30 pct with a polymer dosage of 1.2 lb/ton of dry clay waste. Small-scale continuous tests yielded debrined products containing 20 pct solids using a polymer dosage of 1 lb/ton of dry clay solids. This work is based upon work done under an agreement between the Bureau of Mines, U.S. Department of the Interior, and the University of Alabama.

RI 8742. Effects of Impurities in Electrolytes on Electrowinning of Lead From Lead Chloride, by D. C. Fleck, R. G. Sandberg, and M. M. Wong. 1983. 8 pp. 1 fig. The Bureau of Mines, in a cooperative research program with four lead companies, has investigated ferric chloride leaching of galena to prepare lead chloride for molten-salt electrowinning to produce lead metal. The hydrometallurgical-electrolytic process is an alternative to the sintering-smelting-refining process currently used to produce lead metal and avoids the environmental problems associated with a conventional smelter. During investigations on the electrowinning aspects of the work, it was noted that certain cations, moisture, and sulfate in the electrolyte affect lead metal purity, cell voltage, current efficiency, and viscosity of the electrolyte. Results of bench-scale tests are reported on the effects of CaCl_2 , CuCl_2 , FeCl_2 , MgCl_2 , NaCl , ZnCl_2 , PbSO_4 , and moisture on electrolysis. As impurities increased in the electrolyte, current efficiency decreased. CaCl_2 , CuCl_2 , and FeCl_2 decreased current efficiency by 12 to 47 pct. ZnCl_2 gave a small voltage increase, while CaCl_2 addition equivalent to 4.9 pct Ca caused a 50-pct increase in voltage. The lead metal was contaminated in direct proportion to the CuCl_2 buildup in the electrolyte. Anode corrosion was observed with MgCl_2 and $\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$. Viscosity increased appreciably with the buildup of NaCl , CaCl_2 , and sulfate. Electrolyte foaming occurred with ZnCl_2 , $\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$, MgCl_2 , $\text{FeCl}_2 \cdot 2\text{H}_2\text{O}$, and FeCl_2 . Moisture inhibited the coalescence of the lead metal.

RI 8743. Coal Cutting Mechanics and Noise Generation, by Roy C. Bartholomae and R. S. Becker. 1983. 28 pp. 15 figs. This Bureau of Mines report presents the results of a laboratory investigation of coal cutting mechanics and noise. These experiments were performed using a linear cutting apparatus that operates over a broad cutting speed range. The influence of several coal cutting parameters on the noise, force, productivity, and specific energy

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associated with linear cuts was ascertained. Some basic theoretical aspects of coal cutting mechanics and noise generation are discussed, and the results of the laboratory experiments are used to formulate analytical models of the coal cutting forces and noise. The analytical model for coal cutting noise is then generalized to account for the more important effects of rotary cutting. Based on the generalized model, an estimate of the sound pressure level at an operator's position is made for a typical continuous mining machine. It is concluded that by employing linear rather than rotary cuts, using deeper depths of cut, slower cutting speeds, and more efficient cutting tools, it is possible to reduce the level of coal cutting noise, as well as provide benefits to other important areas of health and safety in underground mining.

RI 8744. Leaching Rates for the HCl Extraction of Aluminum From Calcined Kaolinitic Clay, by R. S. Olsen, S. J. Bullard, W. G. Gruzensky, R. V. Mrazek, and J. L. Henry. 1983. 11 pp. 4 figs. The Bureau of Mines is engaged in research to recover aluminum from kaolinitic clay and other nonbauxitic domestic resources. As part of this work, calcined Georgia kaolin was prepared by a process that prevents slime formation and makes the leached residues fast settling and easy to filter. The leaching reaction for calcined kaolinitic clay in a 5 pct stoichiometric excess of boiling 23- to 26-pct HCl was found to be zero order. Rate constants based on the weight-fraction of aluminum in the clay were found to be between 0.095 and 0.15 min⁻¹ depending on feed preparation and leaching parameters. The mathematical relationships between aluminum extraction and time for both batch and continuous, stirred-tank operations were derived and verified experimentally.

RI 8746. Low-Rank Coals and Waste Materials for Reduction Roasting and Metallization of Iron Oxides, by Roy E. Peterson and Warren M. Mahan. 1983. 17 pp. 9 figs. The Bureau of Mines conducted bench-scale research to evaluate materials that showed potential as low-cost reductants for use in the ironmaking industry. These materials were lignite, subbituminous coal, coal char, tree trimmings, refuse-derived paperboard, used crankcase oil, and peat. To compare their effectiveness, the materials were tested in the reduction roasting of nonmagnetic taconite and, except for oil and peat, in the reduction of iron oxide pellets to metallized pellets. Reduction was conducted in a 18-cm-diameter rotary drum, which was externally heated in an electric furnace. Over 92 pct of the iron was magnetically recovered from a nonmagnetic taconite after roasting with any of the reductants, but greater quantities of reductant were required to achieve this when the waste materials were used. The fossil fuels were also more effective for metallizing pellets, although metallization above 90 pct were also obtained with tree trimmings and refuse paperboard. However, refuse paperboard had to be frequently recharged to the furnace because it depleted rapidly.

RI 8747. Development of a Soft-Soldering System for Aluminum, by W. L. Falke, A. Y. Lee, and L. A. Neumeier. 1983. 15 pp. 9 figs. The Bureau of Mines has developed a system that permits the "soft" soldering of aluminum and aluminum alloys with standard tin-lead solders. The method employs application of a thin nickel-copper-alloy coating to the substrate, which enables the tin-lead solders to wet readily and spread over the areas to be joined. With conventional technology, aluminum and aluminum alloys are extremely difficult to solder be-

cause tenacious surface oxide films prevent wetting. With the Bureau-developed method, the aluminum substrate is mechanically or chemically cleaned to facilitate bonding to a minute layer of zinc that is subsequently applied with an electroless zincate solution. The nickel-copper-alloy (30 to 70 pct Ni) coating is then applied electrolytically over the zinc, using immersion cell or brush-coating techniques. Development of acetate electrolytes has permitted deposition of the proper alloy coatings. The coated areas can then be readily joined with conventional tin-lead solders and fluxes. The joints so formed are ductile, strong, and relatively corrosion resistant, and exhibit strengths equivalent to those formed on copper and brass when the same solders and fluxes are used. The method has also been employed to soft-solder magnesium alloys.

RI 8748. Determination of Bit Forces Encountered in Hard Rock Cutting for Application to Continuous Miner Design, by Sam G. Demou, Richard C. Olson, and Carl F. Wingquist. 1983. 24 pp. 23 figs. Drag bit cutting tests were conducted chiefly to determine bit forces encountered in rock types representing a range of compressive strength and hardness and thus enable the design engineer to estimate a continuous miner's performance in a range of rock types. Testing was carried out on the Bureau of Mines uniquely designed, instrumented rock cutting device (RCD). This device can make 3-ft-long cuts at various depths and speeds to approximate full-scale drag bit cutting by continuous miners. Point attack and cutter bits were tested on four rock types ranging in compressive strength from 7,200 psi (trona) to 29,600 psi (Valders white rock). Cutting tests were made at depths up to 1 in and speeds up to 70 in/sec. Data included normal and cutting forces, groove depth, groove width, and weight of rock broken. The effect of varying the cutting speed was determined, and specific energies were calculated for the various conditions. The bit wear was also observed. For the rocks tested, compressive strength and hardness are good indicators of forces, specific energy, and wear encountered. Results, especially bit wear observations, show the possibility of extending continuous miners, already being used in trona, to Indiana limestone (10,000 psi). Rapid bit deterioration precludes use in Tennessee marble (16,800 psi) and Valders white rock (29,600 psi).

RI 8749. Selective Nickel Electrowinning From Dilute Electrolytes, by G. R. Smith, W. R. Thompson, and P. E. Richardson. 1983. 20 pp. 15 figs. Critical and strategic metals are often present in small quantities in low-grade domestic ores. When these ores are leached, the resulting solution usually contains the metals in very dilute quantities. Selective electrowinning from dilute electrolytes was investigated by the Bureau of Mines. A metal deposit containing 84 pct nickel was electrowon from the leach solution of a complex domestic ore bulk flotation concentrate originally containing approximately 2 wt-pct nickel. Key to achieving accelerated deposition rates, in the case of dilute solutions, is the rapid movement of the electrolyte through the electrowinning cell. Pure, synthetic nickel electrolytes were used to establish deposition parameters, and to optimize electrolyte velocity or mass transfer rates. Hydrodynamic and electro-deposition parameters for both the synthetic and leach electrolytes are presented and the experimental research described. Selective electrowinning appears to offer a viable alternative to physical separation methods to obtain separate metal "concentrates" from low-grade ores.

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RI 8750. **Characterization of Steelmaking Dusts From Electric Arc Furnaces**, by Stephen L. Law, Wayne F. Lowry, Janet G. Snyder, and Gary W. Kramer.

1983. 26 pp. 2 figs. The Bureau of Mines characterized 32 bulk samples of electric arc furnace steelmaking dust for chemical, physical, and extraction procedure (EP) toxicity properties to provide a basis for resource recovery decisions. Surface areas, densities, weight loss on drying, and semi-quantitative data on 48 elements were obtained. Quantitative values for Ag, Al, Ba, Br, C (total and free), Ca, Cd, Cl, Co, Cr, Cu, F, Fe, K, Mg, Mo, Na, Ni, NO₃, P, S (total and sulfate), Si, Sn, Ti, V, and Zn were obtained for each sample. Arsenic and selenium were determined in selected samples. The valence states of Cr, Fe, and Zn were obtained for all samples. The EP toxicity test for hazardous waste classification resulted in 29 of the 32 dusts exceeding the criteria for listing as a hazardous waste. Leached Cd, Cr, and Pb were the problem in each case, with selenium also high in several of the leachates. Density separation studies show a trend for zinc and lead to be more concentrated in less dense fractions and chromium in the more dense, though the extremely fine particle size (generally < 0.2 μm) will probably preclude physical separation as a viable resource recovery option.

RI 8751. **Enthalpy of Formation of 2CdO • CdSO₄**, by H. C. Ko and R. R. Brown. 1983. 4 pp. The Bureau of Mines maintains an active program in thermochemistry to provide thermodynamic data for the advancement of mineral science and technology. As part of this effort, the standard enthalpy of formation at 298.15 K, ΔH_f^o, for 2CdO • CdSO₄ was determined by HCl acid solution calorimetry to be -345.69 ± 0.61 kcal/mol.

RI 8752. **Low-Iron Cu-Ni-Co Matte From Duluth Complex Sulfide Concentrate by Direct Smelting**, by I. D. Shah, P. L. Ruzzi, and R. B. Schluter. 1983. 10 pp. 8 figs. The copper-nickel ore of the Duluth Gabbro Complex in northeastern Minnesota is a large potential domestic resource of cobalt and platinum-group metals. However, because of the low grade of the primary metal values (0.5 pct Cu, 0.15 pct Ni), the private sector has assigned a relatively low priority to the development of technology for processing this ore, anticipating that mining probably would not begin until the mid-1990's. Furthermore, preliminary processing flowsheets considered by the mining companies centered on the primary metal values. As part of an effort to help provide the basis for technology to recover critical and strategic minerals from domestic resources, the Bureau of Mines is investigating methods to recover all of the mineral values, in the Duluth Gabbro material, with particular attention to the byproduct critical minerals. A key step in this process is the removal of a relatively large amount of iron present in the bulk sulfide flotation concentrate to permit subsequent extraction of mineral values. This report describes a direct smelting method that removes most of the iron and produces a copper-nickel-cobalt matte, an intermediate product from which the metal values subsequently are separated. Copper, nickel, and cobalt grade and recovery data are presented for the direct smelting method. Test results showed that under certain conditions some of the mineral values reported to the slag, requiring slag cleaning to recover them.

RI 8753. **Laboratory Investigations on the Behavior of Accessory Elements in Lead Blast Furnace Smelting**, by Elizabeth A. Johnson, L. L. Oden, and John N.

Koch. 1983. 17 pp. 8 figs. The effect of slag composition on lead losses to slags and on the behavior of associated accessory elements in lead blast furnace smelting has been studied by the Bureau of Mines. Equilibrations of 30 g of lead and synthetic slag doped with Cu, In, Tl, and Sb at 1,200° C in CO-CO₂ atmospheres revealed the importance of the FeO:SiO₂ ratio and the basicity ratio, (CaO+MgO):SiO₂, of the slag. Lead losses to slags increased with an increasing FeO:SiO₂ ratio and decreased with an increasing basicity ratio. Copper and indium distribution coefficients,

$$L_x = \frac{\text{wt-pct X in bullion}}{\text{wt-pct X in slag}}, \text{ increased from 15 at the}$$

lower basicity ratios to near 60 at higher basicity ratios. L_{Tl} values increased from 20 to 150 as slag basicity increased. L_{Cu}, L_{In}, and L_{Tl} were relatively independent of the FeO:SiO₂ ratio, but increased with greater amounts of accessory elements in the system. Antimony distribution alone was shown to be strongly affected by FeO:SiO₂ ratio, although data were scattered. L_{Sb} values ranged from 20 to 800 and decreased sharply with increasing FeO:SiO₂ ratios. The basicity ratio and the level of accessory element load did not have any noticeable effect on L_{Sb}.

RI 8754. **Compatibility of Nickel Electrolyte Containing Sodium Sulfate With a Solvent Extraction System**, by Ruth A. Holmes, D. N. Nilsen, and R. E. Siemens. 1983. 12 pp. 6 figs. A Bureau of Mines method for recovering nickel, cobalt, and copper from low-grade domestic laterites is described, which includes the unit operations of solvent extraction and electro-winning. Previous Bureau work indicated that addition of Na₂SO₄ (sodium sulfate) to the nickel electrolyte improved current efficiency in nickel electro-winning. The present study determines the compatibility of Na₂SO₄ with nickel stripping in the solvent extraction operation of the Bureau method. The effect of adding 100 g/l Na₂SO₄ on nickel stripping, phase disengagement, and pH was determined in comparative laboratory-scale tests. In continuous-circuit testing, Na₂SO₄ reduced stripping efficiency to the extent that five, instead of four, strip stages were required for complete stripping of nickel from the loaded solvent. In tests made in a phase-disengagement cell that had a variable settler area, the addition of Na₂SO₄ did not significantly affect phase separation characteristics. The pH of the nickel electrolyte in the temperature range of 20° to 65° C was also unaffected by the addition of Na₂SO₄. An economic evaluation showed that the energy saved by adding Na₂SO₄ to the electrolyte would more than offset the cost of adding another stripping stage.

RI 8755. **Preliminary Evaluation of Bit Impact Ignitions of Methane Using a Drum-Type Cutting Head**, by David A. Larson, V. William Dellorfano, Carl F. Wingquist, and Wallace W. Roepke. 1983. 23 pp. 21 figs. Preliminary laboratory experiments have been conducted by the Bureau of Mines to define the influence of bit geometry on methane ignitions as a step toward establishing safer mining-machine operating parameters. The experimental system was designed to simulate the operation of a continuous mining machine, using a drum-type cutterhead of normal diameter with a narrow cross section, permitting full-diameter drum cutting tests to be run on material representative of sandstone lenses (or inclusions) in coal seams. Two conical bit types were tested at shallow depths of cut with three drum speeds. Bits that rotated in the mounting block

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during testing did not produce ignitions. The ignition frequency for used bits was three to four times greater than for new bits at the same kerf depth.

RI 8756. Selective Recovery of Arsenic From Aqueous Solutions With Hydrated Titanium Dioxide, by B. W. Madsen and D. A. Martin. 1983. 8 pp. 10 figs. Bureau of Mines research to recover arsenic from mining industry waste material and process streams is reported. Batch and column approaches were investigated for adsorbing arsenic from acid leach solutions and ion-exchange eluate solutions with hydrated titanium dioxide granules. A method for producing hydrated titanium dioxide granules was devised to provide material suitable for use in a packed adsorption tower. Selective adsorption of arsenic from acidic leach solutions was achieved. The loading capacity of arsenic on the granules was 14 wt-pct when synthetic solutions were used, but lower when actual leach solutions were used. Other elements in the leach solution were Zn, Cd, and In. The granules were used in an attempt to lower the arsenic content in a solution containing 0.95 g/l W and 0.027 g/l As from a process devised by the Bureau of Mines to treat Searles Lake brine. The arsenic content was lowered to less than 0.001 g/l, but unacceptable amounts of tungsten also were adsorbed by the granules. Adsorbed tungsten was partially stripped with pH 11.5 NaOH, and both tungsten and arsenic were completely stripped with 5M NaOH solution. Repeated loading and stripping of the granules had no effect on the loading capacity for arsenic.

RI 8757. Hydrometallurgical Treatment of Electronic Scrap Concentrates Containing Precious Metals, by H. E. Hilliard, B. W. Dunning, Jr., and H. V. Makar. 1983. 15 pp. 5 figs. The Bureau of Mines investigated processed hydrometallurgical procedures for removing base metals from mechanically processed fractions of obsolete military electronic scrap. Feed material was a minus ¼-in nonmagnetic metallic concentrate produced by high-tension separation. Aluminum was extracted from the feed material in the first-stage ambient temperature, 20-wt-pct sodium hydroxide leach, which was followed by incineration to remove organic matter. A portion of the soluble nickel was extracted in the second-stage oxidizing dilute sulfuric acid leach. Copper and the remainder of the soluble nickel were extracted in the third-stage oxidizing concentrated sulfuric acid leach; copper was recovered from the spent leachate by cementation with an iron-base magnetic fraction. The third-stage leach residue and leachate contained essentially all of the precious metal values.

RI 8758. Corrosion-Resistant Sulfur Concretes, by William C. McBee, Thomas A. Sullivan, and Bing W. Jong. 1983. 28 pp. 23 figs. Sulfur concretes have been developed by the Bureau of Mines as construction materials with physical and mechanical properties that suit them for use in acid and salt corrosive environments where conventional concretes fail. Mixture design methods were established for preparing sulfur concretes using different types of aggregates and recently developed mixed-modified sulfur cements. Bench-scale testing of the sulfur concretes has shown their potential value. Corrosion resistance, strength, and durability of sulfur concrete are superior to those of conventional materials. Field in situ evaluation tests of the sulfur concretes as replacement for conventional concrete materials are in progress in corrosive areas of 24 commercial chemical, fertilizer, and metallurgical plants.

RI 8759. Alumina Miniplant Operations—Overall Mass Balance for Clay-HCl Acid Leaching, by Dwight L. Sawyer, Jr., Theodore L. Turner, and Don B. Hunter. 1983. 29 pp. 10 figs. To provide technology that can help decrease the dependence of the U.S. aluminum industry on imported bauxite, the main ore of aluminum, the Bureau of Mines is investigating the extraction of aluminum from abundant domestic reserves of kaolinitic clay. Miniplant studies of the continuous leaching of calcined kaolin with boiling 25-pct HCl acid resulted in a 93- to 99-pct extraction of the acid-soluble alumina in the calcined kaolin feed. Data are presented for an acid leaching study carried out in three or four continuously stirred tank reactors (CSTR) in series, feed rates of 100 to 250 lb/hr of calcined kaolin, and total nominal residence times of 0.7 to 2.3 hr. A material balance for a 176-lb/hr calcined kaolin feed rate in a circuit consisting of three reactors, four classifiers, and five thickeners is given. Data provide detailed compositional and physical information for calcined kaolin, process liquors, and acid-leached residue solids.

RI 8760. Recovery of Chromium From Surface-Finishing Wastes, by H. O. McDonald and L. C. George. 1983. 8 pp. 1 fig. The Bureau of Mines has demonstrated a hydrometallurgical method to separate chromium from other metals in a variety of surface-finishing wastes by precipitation with benzoate ion. The resulting chromium salt may then be converted to the hydroxide, and the benzoate may be recycled. Chromium recoveries of 92 to 100 pct are obtained.

RI 8761. Effect of Asymmetric Wear of Point Attack Bits on Coal-Cutting Parameters and Primary Dust Generation, by Wallace W. Roepke and Bruce D. Hanson. 1983. 16 pp. 8 figs. The Bureau of Mines conducted a series of experiments using Illinois No. 6 coal to determine the effect of asymmetric wear on airborne respirable dust (ARD), specific energy, cutting force, and normal force. Plumb-bob-type bits—one new bit and four ground with different sized flats—were used. Constant-depth linear cuts at the 0.32, 0.64, 1.27, and 2.54-cm cut depths were made. Both cutting force and normal force increased as the flat area increased. Specific energy demonstrated a statistically significant increase with flat area at the 0.32- and 1.27-cm cut depth only. Specific ARD showed a statistically significant decrease with increasing flat area only at the 0.64-cm cut depth. Increasing cut depth increased cutting force but decreased specific energy and specific ARD. Normal force increased with increasing cut depth for the new bit but exhibited a maximum at 0.64 cm for the bits with flats.

RI 8762. Calamity Hollow Mine Fire Project (In Five Parts). 1. Development and Construction of the Burnout Control Ventilation System, by Meherwan C. Irani, Robert F. Chaiken, Louis E. Dalverny, Gregory M. Molinda, and Karen E. Soroka. 1983. 29 pp. 29 figs. The Bureau of Mines is developing a new technological approach to handling the problems of fires in abandoned coal mines and waste banks. This new technology involves the accelerated combustion of "waste" coals in place (i.e., in situ) under controlled exhaust ventilation conditions, which allows for total management of the combustion products, including utilization of the heat produced. This new concept could significantly lower the costs of reducing the environmental and public safety hazards associated with waste coal fires, and could lead to the conversion of a coal waste to a coal

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resource. The controlled burnout technology has progressed from the laboratory stage to a full-scale field evaluation stage at the site of an abandoned-coal-mine fire. This first report describes the site selection, evaluation, and preparation, and the design and construction of the full-scale controlled burnout installation. Subsequent reports will deal with the results of the operational field trial.

RI 8763. Pilot Mill Flotation of Anorthositic Platinum-Palladium Ore From the Stillwater Complex, by E. Morrice. 1983. 8 pp. 2 figs. The Bureau of Mines investigated methods for beneficiating platinum-group metal ores from the Stillwater Complex, Montana, as part of its program to increase the supply of critical and strategic minerals and metals from domestic resources. This report presents results of a 5-day continuous campaign employing a pilot flotation mill to recover sulfide concentrate containing platinum-palladium values from anorthositic ore. A mercaptobenzothiazole-sulfuric acid reagent suite was used. The pilot flotation mill was operated at an average feed rate of 106 lb/hr of ore. A rougher concentrate containing 8.5 pct of the feed was prepared; it assayed 1.1 oz/ton Pt and 3.5 oz/ton Pd. Recovery of platinum and palladium were 91 and 87 pct, respectively.

RI 8764. Velocity and Orientation Effects on the 10-mm Dorr-Oliver Cyclone, by Andrew B. Cecala, Jon C. Volkwein, Robert J. Timko, and Kenneth L. Williams. 1983. 11 pp. 9 figs. The Bureau of Mines conducted a brief laboratory study on the 10-mm-diam Dorr-Oliver nylon cyclone to investigate (1) whether high wind speed (> 300 ft/min), or sampler inlet orientation with respect to wind direction, can introduce errors when sampling respirable dust, and (2) whether any such errors can be reduced by using an inlet shield. Being preliminary in nature, the study was not structured to produce definitive results, but rather to discern likely trends and to indicate whether or not a more in-depth study of the problem is warranted. Photometric mass sensing measurements suggested that as the wind velocity increased, the cyclone sampling directly into the high-velocity airstream tended to oversample, relative to the cyclone sampling in a low-velocity airstream. Orientation of the sampler introduced measurable differences in sampling efficiency at higher wind velocities. A shield placed around the cyclone diminished the effects of wind velocity and sampler orientation on sampler performance. Results of this work offer sufficient evidence to substantiate the need for a more in-depth study.

RI 8765. General Time-Dependent Solutions for Radon Diffusion From Samples Containing Radium, by P. J. Dallimore and R. F. Holub. 1983. 49 pp. 10 figs. The Bureau of Mines has calculated general time-dependent solutions for radon diffusion from cylindrical and slab rock samples containing uniform radium distribution. Results have been obtained for several sets of boundary conditions. The method is suitable for determining the effective diffusion coefficient and the effective porosity for radon.

RI 8766. Extracting Vanadium and Uranium From Low-Grade and Mill-Grade Ores From the Colorado Plateau, by I. L. Nichols, G. R. Palmer, and J. L. Huiatt. 1983. 16 pp. 9 figs. The Bureau of Mines is investigating vanadium recovery from various domestic resources. A low-grade carnotite ore sample containing 0.34 pct V_2O_5 and 0.04 pct U_3O_8 was leached, and the results were compared with

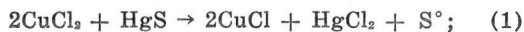
those of similar leach tests using a mill-grade sample containing 1.26 pct V_2O_5 and 0.19 pct U_3O_8 . Experiments on the two ore samples included agitation leaching, pugging, salt-roast leaching, and autoclave leaching. None of the leaching methods investigated showed any significant advantage over another except autoclaving, which reduced the leach time but at the expense of greater acid consumption. Typical of the experimental results attained are the data gathered from the agitation leaching tests. Agitation leaching of the mill-grade ore with 100 lb/ton H_2SO_4 resulted in extractions of 94 pct U_3O_8 and 33 pct V_2O_5 . To increase the vanadium extraction from 33 to 91 pct required concentrations of 300 lb/ton H_2SO_4 and 10 lb/ton $NaClO_3$. Complementary agitation leach tests on the low-grade ore required 200 lb/ton H_2SO_4 to extract 94 pct U_3O_8 , and 300 lb/ton H_2SO_4 and 10 lb/ton $NaClO_3$ to extract 90 pct V_2O_5 .

RI 8767. Long-Term Effectiveness of Deep Mine Sealing at Moraine State Park, Butler County, Pa., by Slavoljuk D. Maksimovic and Bernard R. Maynard. 1983. 35 pp. 17 figs. The Bureau of Mines conducted water sampling with flow measurements at Moraine State Park to determine the long-term effectiveness of the deep mine sealing completed between 1969 and 1971. Data collection in 1979 and 1980 consisted of taking two samples per weir location from a group of mine entries. These data were compared with baseline data from before and 1 year after seal completion, utilizing standard statistical procedure. The total mean water discharge and total mean iron load increased, whereas the mean acid load decreased. The minimum water discharge, minimum acid, and total minimum iron load increased, and the maximum water discharge, maximum acid, and total maximum iron load decreased as a result of sealing. The acid load variance was reduced approximately 55 pct. The water discharge and water quality were more consistent than before sealing. In general, the water quality was better within a mine pool than at the discharge points; the development of a pool did not insure improvement at the discharge points. Overall, mine sealing improved the water quality in the park's Lake Arthur.

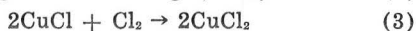
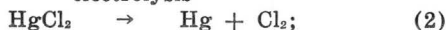
RI 8768. Mathematical Modeling of Accessory Element Distribution in Metallurgical Processes—Computerization of a Lead Smelter Plant, by M. A. Lucas, C. M. Flynn, Jr., and T. G. Carnahan. 1983. 46 pp. 3 figs. The Bureau of Mines has developed a computerized mathematical model to predict the distribution of accessory elements throughout a metallurgical process. The model can be used to determine process conditions that effect better accessory element control consistent with continued high primary metal recovery. The model presented is specific for determining the bismuth distribution in lead smelting but can be adapted to most extractive metallurgical processes. Thermodynamic, kinetic, and process parameters form the base for the model. Its logic and structure are described in detail.

RI 8769. Recovering Mercury From a Flotation Concentrate by Continuous Leaching-Electrolysis, by G. B. Atkinson, J. E. Murphy, and J. A. Eisele. 1983. 9 pp. 4 figs. The Bureau of Mines, in cooperation with McDermitt Mine, investigated a method for recovering mercury metal from mercury sulfide flotation concentrate by a hydrometallurgical technique. This preliminary report shows the feasibility of leaching mercury with a cupric chloride solution and electro-winning mercury from the solution. Proposed chemical reactions are shown in equations 1 through 3:

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electrolysis



A bench-scale leaching-electrowinning apparatus capable of treating 2.36 kg of sulfide concentrate in 11 days was operated continuously. An acid chloride solution containing, in grams per liter, 70 Ca, 60 Cu, 30 Fe, and 80 Hg was used as both leachant and electrolyte; 99.5 pct of the mercury was solubilized from the sulfide concentrate. Electrolysis of the leaching solution recovered mercury metal at an average current efficiency of 32 pct and an average energy consumption of 1.2 kwhr/lb Hg. Results from a preliminary economic evaluation indicated that a plant producing 31,500 flasks of mercury per year would have a capital cost of \$3.7 million and an operating cost of \$62 per flask of mercury.

RI 8770. Integrated Operation of Ferric Chloride Leaching, Molten-Salt Electrolysis Process for Production of Lead, by M. M. Wong, R. G. Sandberg, C. H. Elges, and D. C. Fleck. 1983. 21 pp. 16 figs. The Bureau of Mines, under a cooperative research program with four lead companies, has investigated a nonmelting process for the production of lead metal. The process, which would eliminate sulfur dioxide generation and minimize particulate lead emissions, involves ferric chloride leaching of galena concentrate to produce lead chloride, followed by molten-salt electrolysis of the lead chloride to yield lead metal and chlorine. This chlorine is used to regenerate ferric chloride in the leaching solution. The process was tested in an experimental unit with a capacity of 500 lb of lead metal per day. The tests were performed in three 10-day and six 5-day campaigns, during a period spanning 28 mo. The study was carried out using a southeastern Missouri lead concentrate. Typical lead recovery was about 98 pct. Process problems related to impurity build-up and control were studied. When copper and silver impurities were removed from the leaching solution, a lead metal purity of 99.999 pct was obtained. Lead-in-air levels and lead-in-blood levels of operating personnel were monitored. The process has potential for producing lead with minimum pollution, but is not ready for commercial utilization. Operation of a prototype commercial electrolytic cell and a full-scale pilot-plant investigation by industry are needed to evaluate the commercial viability of the process.

RI 8771. A Water Elutriator System for Recovering Nonmagnetic Metals From Automobile Shredder Rejects, by D. K. Steele and J. W. Sterner. 1983. 22 pp. 10 figs. An 18-in-diam column water elutriator was designed, tested, and operated by the Bureau of Mines for recovering nonferrous mixed metals from automobile shredder rejects. The water elutriator separated metals from nonmetals contained in shredded nonmagnetic rejects. The unit was constructed and integrated into a local automobile shredding operation. Nonmagnetic rejects from the automobile shredder were fed onto the surface of a column of rising water. Dense materials fell through the rising water and were collected as a sink product at the bottom of the column; medium-density materials were removed as an intermediate product in a water flow through a discharge port located between the overflow and sink; and light materials were immediately carried out in the overflowing water at the top of the column as a float product. Nearly 99 pct of the mixed metals were recovered

from the nonmagnetic rejects as a 70-pct-metal concentrate. Other operating conditions yielded a 93.7-pct-pure-metal product resulting in a 93.1-pct metal recovery. Float rejects are combustibles, light plastics, foam rubber, and minimal amounts of coated and uncoated copper wire. The middling discharge contained mainly medium-density rubber, plastics, glass, rock, coated and uncoated wire, and frequently some thin-sheet stainless steel and wrought aluminum. Maximum metal recovery in the operating program was achieved using a water velocity of 52 fpm (650 gpm). Maximum purity was obtained with a velocity of 88 fpm (1,100 gpm). Water was recycled through a 12,000-gal baffled clarifying tank. Entrainment water losses with the float and middling rejects averaged 50 gpt of reject feed. Records maintained by the shredder operator show a 34-pct increase in nonmagnetic metals recovery during a 1-yr operation of the water elutriator as compared to recoveries from a previously used air classification system. This report is based upon work done under an agreement between the Bureau of Mines and Learner-Pepper Co., Salt Lake City, UT.

RI 8772. Factors Affecting the Preparation of Misted Clay Feed and Solids-Liquid Separation After HCl Leaching, by R. S. Olsen, W. G. Gruzensky, S. J. Bullard, and Jack L. Henry. 1983. 25 pp. 17 figs. Although aluminum is easily leached from calcined clay with boiling mineral acids, the presence of fines and slimes in the leached residue has hindered the application of acid leaching processes. A feed preparation method was, therefore, devised that provided a dense, smooth-surfaced, fine-grained clay. The important factors affecting feed quality were determined to be (1) crushing the raw clay to the size desired for the leaching process, (2) moistening the crushed clay with a fine mist of water while tumbling on a rotating disk, (3) drying the misted clay, and (4) calcining the dried clay at 750° C in a fluidized bed. Clay treated by this method was leached with HCl, and its residue was washed by water displacement in 4-ft-deep beds. Bed permeabilities on the order of 47 darcys or $4.6 \times 10^{-7} \text{ cm}^2$ were obtained with the leached residues.

RI 8773. Mechanical Properties of Some Portland Cement Concretes Made With Coal and Coal Waste as Aggregates, by Bing W. Jong and William C. McBee. 1983. 12 pp. 6 figs. A bench-scale evaluation of coal and coal waste materials as aggregate materials for use in longwall mine supports was undertaken as part of the Bureau of Mines Health and Safety program on ground control. Performance data were obtained on portland cement concretes (PCC) prepared with coal and coal wastes as aggregate materials. The effects of high-early-strength accelerators on strength and creep and of superplasticizers on strength properties of PCC formulated with coal and coal waste were investigated. Concrete formulated with a high-early-strength accelerator and coal and coal waste has 20 and 40 pct greater compressive strength, respectively, than the control samples without admixture. A concrete formulated with coal waste and the high-early-strength accelerator, using four bags of cement per cubic yard and a water-cement ratio of 1.0, had the lowest creep value of all the coal- and coal-waste-formulated PCC's tested.

RI 8774. A Digital Instrumentation Package for an Improved Torsion Pendulum, by R. W. Nash and A. E. Schwaneke. 1983. 9 pp. 6 figs. This report describes the design and operation of a digital instrumentation package for the Bureau of Mines im-

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proved torsion pendulum, a scientific instrument that measures the vibration damping of metallic materials. The new design eliminates manual analog-to-digital conversion, reduces the data acquisition time, and increases the precision of the measurements. The digital output can be coupled directly to a microprocessor or computer to produce the final data in real time.

RI 8775. An Evaluation of Aluminum Smelter Potlining as a Substitute for Fluorspar in Cupola Iron-melting and in Basic Oxygen Steelmaking, by Victor R. Spironello. 1983. 18 pp. 3 figs. The Bureau of Mines has studied slags associated with ferrous melting, to evaluate substitutes for the auxiliary flux mineral, fluorspar. A waste material recovered from alumina reduction cells, "used potlining," was tested in an 18-in-ID basic-lined cupola and in a ¼-ton, pilot-scale, basic oxygen furnace (BOF). One potlining fraction, No. 1 cut, is a carbonaceous (graphitic) material and represents the bulk of the entire cell lining. The other fraction, No. 2 cut, is a refractory backup. These materials contain significant quantities of fluorine, and other elements in various compounds. The potlining fractions were blended in ratios believed representative of available materials. Both lump and pelletized forms provided extremely fluid slag. No adverse effects were found on furnace performance, chemistry or strength of the metals produced, or the environment. Fluorine recovery in the slag and fluorine losses to the scrubber water and solids were about the same as when fluorspar was used. There was apparently no lining loss from the cupola, but there was lining attack in the BOF. Since the fluidizing ability of potlining is due in part to sodium and other elements such as aluminum and silicon, less fluorine is needed in the slags when potlining is used.

RI 8776. Evaluation of Radium and Toxic Element Leaching Characteristics of Florida Phosphogypsum Stockpiles, by Alexander May and John W. Sweeney. 1983. 18 pp. 2 figs. The Bureau of Mines conducted studies to determine if phosphogypsum, a waste material from the processing of phosphate rock, contains hazardous toxic materials as defined by the Environmental Protection Agency (EPA) and whether leaching of these toxic materials and radium may occur. Samples of the phosphogypsum stockpiled material were evaluated using the EPA extraction procedure, atomic absorption, neutron activation, X-ray diffraction, and chemical and physical means. Radiological tests performed used both the germanium-lithium and emanation methods. The data show that the phosphogypsum stockpiles are not hazardous toxic waste as defined by EPA criteria. Trace elements and radium are not leached from the phosphogypsum stockpiles. Absorption of trace elements and radium by phosphogypsum is the major reason for their not being leached. The standard error of measurement of radium concentrations was 4.7 pCi/g. Research at the Tuscaloosa Research Center is carried out under a memorandum of agreement between the Bureau of Mines, U.S. Department of the Interior, and the University of Alabama.

RI 8777. Correlation of LANDSAT and Air Photo Linears With Roof Control Problems and Geologic Features, by Jacqueline H. Jansky and Ronald F. Valane. 1983. 22 pp. 23 figs. The Mine Safety and Health Administration (MSHA), U.S. Department of Labor, did a linear analysis for a new underground coal mine in Grant County, WV, through the inter-

pretation of LANDSAT imagery and high-altitude, color-infrared aerial photography, to identify areas of potentially unstable roof in advance of mining. The Bureau of Mines included this mine in its ongoing study of the correlation between geologic features and linears. Three years after the analysis, after mining had progressed through the plotted linears, a cooperative Bureau-MSHA study evaluated the effectiveness of the linear plot in predicting areas of unstable roof and defined the geology associated with the linears. Adverse roof conditions at this mine include roof falls, potted-out roof, water inflow, and local areas requiring supplemental support. At the time of this study, 34 pct of the mine workings were within 200 ft of a plotted linear. Fifty percent of the adverse roof area in the mine occurred within this same area. The primary geologic anomaly associated with the linears is an increased frequency of jointing. The majority of the plotted linears coincide with the prominent joint orientations. Additional features observed in the linear zones include roof rolls and a standstone channel that cuts into the coal seam.

RI 8778. The Enthalpy of Formation of Synthetic Cancrinite $[\text{Na}_{7.05}(\text{Al}_6\text{Si}_6\text{O}_{24})(\text{NO}_3)_{1.05}(\text{H}_2\text{O})_{4.1}]$, by K. O. Bennington and R. R. Brown. 1983. 7 pp. Cancrinite is one constituent of "red muds," a high-volume waste product of alumina production by the Bayer process. The Bureau of Mines determined the thermochemical properties of cancrinite as part of a program to provide such data for minerals of industrial importance. Cancrinite $[\text{Na}_{7.05}(\text{Al}_6\text{Si}_6\text{O}_{24})(\text{NO}_3)_{1.05}(\text{H}_2\text{O})_{4.1}]$ was synthesized by reacting aluminum silicate gel with a solution of NaOH and NaNO_3 , and the composition was determined by chemical analysis, differential scanning calorimetry, and thermogravimetric analysis. The heat of solution was determined by hydrofluoric acid solution calorimetry. The standard enthalpy of formation at 298.15 K, $\Delta\text{H}_f^\circ_{298}$, is

$$\Delta\text{H}_f^\circ_{298} = -3,487.97 \pm 2.6 \text{ kcal/mol,}$$

and the standard enthalpy of formation from the oxides and NaNO_3 , $\Delta\text{H}^\circ_{298}$, is

$$\Delta\text{H}^\circ_{298} = -215.20 \pm 1.8 \text{ kcal/mol.}$$

RI 8779. Thermodynamic Properties of Pollucite (A Cesium-Aluminum-Silicate), by K. O. Bennington, R. P. Beyer, and G. K. Johnson. 1983. 18 pp. The thermodynamic properties of pollucite $[(\text{Cs}_{0.050}\text{Na}_{20.155}\text{Rb}_{0.025})(\text{AlSi}_2)(\text{O}_{5.803}\text{OH}_{0.137}) \cdot 0.19\text{H}_2\text{O}]$ were determined by the Bureau of Mines in collaboration with the Argonne National Laboratory. The standard enthalpy of formation determined by hydrofluoric acid calorimetry is

$$\Delta\text{H}_f^\circ_{298} = -3,098.52 \pm 3.63 \text{ kJ mol}^{-1}.$$

The standard enthalpy of formation from the oxides is

$$\Delta\text{H}^\circ_{298} \text{ (from oxides)} = -209.50 \pm 2.38 \text{ kJ mol}^{-1}.$$

Low-temperature heat capacities were determined by adiabatic calorimetry from 5.0 to 306.1 K. The derived standard entropy is

$$\text{S}^\circ_{298} = 207.20 \pm 0.43 \text{ J mol}^{-1} \text{ K}^{-1}.$$

Enthalpy increments above 300 K were measured by copper-block drop calorimetry from 349 to 674 K. Various experimental data were combined with other data from the literature to calculate the Gibbs energies of formation and equilibrium constants of formation over the temperature range of measurements. Standard enthalpies of formation and Gibbs energies of formation are given as functions of

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temperature. The Gibbs energy of formation is

$$\Delta G_f^\circ_{298} = -2,919.9 \text{ kJ mol}^{-1}.$$

RI 8780. Reducing Longwall Tailgate Workers' Dust Exposure Utilizing Water-Powered Scrubbers, by John A.

Organiscak, Jon C. Volkwein, and Robert A. Janowski. 1983. 11 pp. 8 figs. Laboratory and underground studies were conducted by the Bureau of Mines to evaluate the effectiveness of a water-powered scrubber and a brattice partition to create a clean split of air for longwall workers at the tailgate. In simulated laboratory tests, the system was very effective in creating a clean split of air. Observed system efficiencies were 74 and 84 pct with induced airflows of approximately 2,000 and 2,500 cfm, respectively. Underground evaluations indicated that the system was capable of reducing respirable dust at the tailgate. The first underground evaluation resulted in protection efficiencies of 30.7 and 42.5 pct at scrubber water pressures of 150 and 450 psig, respectively. A 33.7-pct protection efficiency was observed in the second underground evaluation with a modified partition and the scrubber operating at 250-psig water pressure. To be most effective, the system should have the scrubber operating at a flow rate of 10 gpm at 500 psig to deliver a maximum quantity of cleaned air behind a well-sealed partition.

RI 8781. Above-the-Earth Field Contours for a Dipole Buried in a Homogeneous Half-Space, by Steven M.

Shope. 1983. 14 pp. 4 figs. An essential element of the Bureau of Mines electromagnetic location and communication system for trapped miners is a quantitative knowledge of the surface and above-surface electromagnetic fields created by an underground transmitter. The field solutions given in this report use approximations in which the displacement currents are negligible for low frequencies. The earth is represented by a homogeneous half-space model in which a dipole source is immersed. The vertical magnetic field equipotential contours at and above the surface are graphically mapped. The volumes of the regions bounded by these contours are directly related to the geometrical zones of signal detectability. Knowledge of the detectability zones will enable the proper search strategies to be developed for airborne detection of trapped miners.

RI 8782. Physical Property Data on Coarse Anthracite Waste, by Bill M. Stewart and L. A. Atkins. 1983.

24 pp. 17 figs. Since 1974, a large amount of data has been developed concerning the physical properties and stability characteristics of waste generated by the mining and preparation of bituminous coal. However, very little information has been developed on the properties and characteristics of anthracite waste. During this Bureau of Mines research project, coarse anthracite breaker refuse from five sites in eastern Pennsylvania was sampled, and the physical properties, which indicate stability characteristics, were determined in the laboratory. Coarse anthracite breaker refuse is quite similar to coarse bituminous refuse in chemical and mineralogical composition. However, the physical properties of the anthracite waste materials tested are different from those of coarse bituminous refuse. For the coarse anthracite breaker refuse tested, the average maximum laboratory density is 113.2 lb/ft³, the average angle of internal friction (direct shear) and average cohesion are 30.2° and 2.6 psi, respectively, and the average permeability (four sites) is 1.24×10^{-2} cm/sec. Stability analyses were conducted on six theoretical anthracite waste embank-

ments. These analyses show the effects on minimum safety factors of geometry, phreatic surface level, and physical properties.

RI 8783. Copper-Manganese-Base Silverless Brazing Systems, by V. R. Miller and W. L. Falke. 1983.

16 pp. 10 figs. The Bureau of Mines conducted research on substitute brazing filler alloys with properties similar to those of silver filler alloys in an effort to conserve silver and reduce hazards from cadmium emissions. Experimental work was conducted first on the commercial silver brazing alloys BAG-1, BAG-1a, BAG-2, and BAG-3 to establish criteria for evaluating the substitute alloys. Properties investigated included the wettability of copper, brass, and steel substrates, and the strength of joints made with the filler alloys. A series of experimental alloys containing 50 to 60 pct Cu, 20 to 28 pct Mn, and 17 to 30 pct Zn was prepared and evaluated, together with Cu-Mn-Zn alloys with 5 pct Pb or 2 pct Ni. Wetting properties and joint strengths were not as good as those for silver filler alloys, and the high application temperatures reduced the copper and brass base metal strengths. However, experimental alloys containing 70 pct Cu, 15 to 20 pct Mn, and 10 to 16 pct Sn had wetting and strength properties approaching those of the silver filler alloys. The application temperatures for these alloys were higher than those for silver fillers, but not as high as those for the Cu-Mn-Zn alloys. With the Cu-Mn-Sn alloy fillers, copper alloy joint members are less deteriorated by recrystallization than when applying Cu-Mn-Zn alloys. The Cu-Mn-Sn system has potential for further development as a substitute brazing alloy system, particularly if the melting temperature can be reduced by the addition of other elements without decreasing the ductility and wetting.

RI 8784. Toward Development of a Hard-Rock Mining Machine—Drag Cutter Experiments in Hard, Abrasive Rocks, by Roger J. Morrell and Richard J. Wilson. 1983. 19 pp. 13 figs. The Bureau of Mines

conducted drag cutting experiments in hard, abrasive rock in an effort to extend the capabilities of an experimental kerf-core mining machine. The basic kerf-core mining machine cannot be used in hard, abrasive rocks because of the high wear experienced by the kerf cutters. These experiments were conducted in an effort to develop a method of preweakening the rock ahead of the kerf cutters in order to reduce the high cutting loads and hence the higher wear rates experienced by the cutters. The two "preweakening" techniques studied were indenting with mechanical wedges and single and double slotting with diamond saws. The best cutter force reduction achieved with mechanical indenting was 70 pct, whereas double slotting achieved force reductions of up to 99 pct. Conceptual designs of preweakening systems that could be retrofitted onto the basic kerfing cutterhead were developed for both the indenting and the slotting techniques. A high-energy impactor with wedge bit was used for the indenting method, and high-pressure water jets were used for the slotting method. A preliminary technical and economic analysis was performed for both of these full-scale systems to illustrate the methodology and to point out the important technical and economic factors that must be considered.

RI 8785. Kettlebottoms: Their Relation to Mine Roof and Support, by Frank E. Chase and Gary P. Sames. 1983. 12 pp. 14 figs. Kettlebot-

tomms are columnar masses of rock—the preserved casts of ancient tree stumps—embedded in coal mine roof strata (of which they are a part).

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Because unsupported kettlebottoms can detach from a mine roof without warning, they are a hazard to miners. The primary objectives of this investigation were (1) to better define and describe kettlebottoms and (2) to evaluate kettlebottom support techniques in terms of safety and effectiveness. A telephone survey of mine operators, interviews with Mine Safety and Health Administration (MSHA) personnel, and underground mine visits were conducted in Pennsylvania, West Virginia, and Kentucky. Information gathered during this investigation indicates that the size and frequency of kettlebottoms in mine roof are dependent upon past geologic events and biological processes active during the deposition of roof sediments. To ensure the safety of mine personnel, all undermined kettlebottoms should be supported. The roof should be bolted next to kettlebottoms less than 3 ft in diameter, close enough to allow a portion of a wood or steel header to be extended beneath each kettlebottom for support. Two bolts and a wood plank or steel strap should be employed to support kettlebottoms over 3 ft in diameter.

RI 8786. Industrial Evaluation of Sulfur Concrete in Corrosive Environments, by W. C. McBee, T. A. Sullivan, and B. W. Jong. 1983. 15 pp. 13 figs. Over the past several years the Bureau of Mines has developed a sulfur concrete (SC) technology in which chemically modified sulfur is mixed with suitable mineral aggregates to produce construction materials that are resistant to corrosion by acids and salts. Modified SC materials have been tested in actual operating conditions in 50 corrosive process environments at 40 commercial plants. SC components ranging from small test coupons to 4-ton acid sump tanks were fabricated and installed at plant locations where chemical corrosion was destroying conventional concrete materials. Through cooperative agreements with several companies, floors, retaining walls, and foundations were cast in place using SC materials, then monitored for resistance to corrosion and retention of strength properties. After 4 years of testing there was essentially no evidence of material degradation or loss of strength. Conventional concrete materials, however, were attacked and in some cases completely destroyed under the same conditions. Minor degradation, similar to that encountered with portland cement concrete (PCC), occurred when sulfur concrete was exposed to strong alkali, hot chromic acid, and copper slimes solutions. Although long-term aging characteristics of SC materials are still being determined, already these materials are finding widespread use in metallurgical, chemical, and fertilizer processing plants.

RI 8787. Effect of Potassium Ethylxanthate Degradation on Flotation of Chalcopyrite and Molybdenite, by W. Simpson, I. L. Nichols, and J. L. Huiatt. 1983. 8 pp. 4 figs. The Bureau of Mines conducted research to determine the effects of potassium trithiocarbonate (KTTC), a degradation product of potassium ethylxanthate (KEX), on flotation of chalcopyrite and molybdenite. Small amounts of KTTC were identified in fresh and aged solutions of KEX using thin-layer chromatography. Hallimond tube flotation tests on pure minerals showed that KTTC acts as a weak collector for chalcopyrite. Both KEX and KTTC tend to depress molybdenite, but the depression effect is easily overcome by addition of a small quantity of fuel oil. The results of the Hallimond tube tests were confirmed in batch flotation tests using a porphyry copper ore.

RI 8788. Distribution and Analyses of Gold and Silver in Mechanically Processed Mixed Electronic Scrap, by B. W. Dunning, Jr., F. Ambrose, and H. V. Makar. 1983. 17 pp. 6 figs. The Bureau of Mines investigated the concentration and distribution of precious metals in the various fractions produced from mechanical processing of obsolete military electronic scrap. Whole avionic units, printed circuit cards, and electrical connectors were processed and analyzed. Materials recovered included baghouse lights, wire bundles, magnetics, and metal concentrates from eddy-current and high-tension separation. Higher value fractions were processed by a commercial toll refiner for recovery of gold and silver. Lower value fractions were analyzed by the Bureau. Three fractions, the lights, wire bundles, and metallics from high-tension separation, contained most of the precious metals. Depending on the type of scrap feed, these fractions represented 34 to 60 pct of the original sample weight. Collectively, they represented 68 to 97 pct and 75 to 98 pct of the contained gold and silver, respectively.

RI 8789. Synthetic Fluorspar Flux in the Basic Cupola: Evaluation of Operation and Fluorine Volatility, by H. W. Kilau, V. R. Spironello, I. D. Shah, and W. M. Mahan. 1983. 20 pp. 8 figs. The Bureau of Mines evaluated synthetic fluorspar as a substitute for natural fluorspar flux in basic cupola ironmaking. The synthetic fluorspars tested were prepared from waste fluosilicic acid generated during the processing of fluorapatite ore. The cupola trials showed the synthetic products to be the equivalent of natural fluorspar from an operational standpoint. However, wet scrubber sampling showed that substantial losses of volatilized fluorine occurred from the cupola during operation. The losses during synthetic fluorspar trials considerably exceeded those from natural fluorspar trials. Laboratory viscosity testing, using a high-temperature rotational viscometer, confirmed this finding and indicated that fluorspar volatility in slags is related to slag basicity. Synthetic fluorspar is accordingly recommended more for highly basic cupola operation (>1.3 basicity) than for neutral or acid operation, because of the increased potential for pollution and baghouse filter deterioration.

RI 8790. Beneficiation of a Western Mesabi Nonmagnetic Taconite After Reduction Roasting With Lignite, by Roy E. Peterson and John E. Moy. 1983. 19 pp. 9 figs. The Bureau of Mines has been developing and evaluating methods for beneficiating the large deposits of nonmagnetic (oxidized) taconite located on the western Mesabi Range. In this segment of the research, a sample representing about 0.5 billion tons of nonmagnetic taconite from near Grand Rapids, Minn., was beneficiated using a reduction roasting, magnetic separation, flotation process. The sample contained 32.1 pct iron and 49.1 pct silica. Tests were conducted both on a bench scale and with a 1,000-lb/h pilot plant. In the bench-scale research a concentrate containing 69.0 pct iron and 4.5 pct silica was produced with an iron recovery of 82.1 pct. In the pilot plant, reduction roasting was conducted in a 35-ft kiln using lignite as the reductant and major source of fuel. Dust from the kiln exhaust was pelletized and recycled to the kiln. The roasted taconite was beneficiated by magnetic separation and flotation to produce a product containing 67.9 pct iron, 5.5 pct silica, and 69.7 pct of the iron in the kiln feed. The cyclone separation in the grinding circuit was

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sharpened by demagnetizing the cyclone feed in a 400-Hz, 1,000-Oe magnetic field.

RI 8791. Novel Coal-Cutting Bits and Their Wear Resistances, by Lung Cheng, Israel Liebman, Aldo L. Furno, and Richard W. Watson. 1983. 15 pp. 13 figs. Based on earlier tests that showed steel to be much more likely to cause frictional ignition than tungsten carbide, the Bureau of Mines redesigned coal-cutting bits to reduce the hazard of face ignitions. Two bit designs—a mushroom-shaped bit with a conical shank and a dovetail bit with a rectangular shank—are described, as well as bit wear tests conducted in the laboratory and in an operating coal mine. In laboratory tests, for $\frac{1}{8}$ -, $\frac{1}{4}$ -, and $\frac{1}{2}$ -in-deep cuts and cutting speeds of 280, 500, and 660 ft/min, the mushroom bit had significantly longer tip wear life than the conventional bit; the dovetail bit was also superior to the conventional bit. Results of in-mine tests on the mushroom bit agree well with laboratory results. In-mine tests of the dovetail bit are underway.

RI 8792. Corrosion of Selected Metals and a High-Temperature Thermoplastic in Hypersaline Geothermal Brine, by R. K. Conrad, J. P. Carter, and S. D. Cramer. 1983. 20 pp. 7 figs. The Bureau of Mines conducted corrosion research to determine suitable construction materials for geothermal resource recovery plants. Weight loss, pitting, and crevice corrosion, U-bend stress corrosion, and electrochemical polarization measurements were made on selected metals in brine and steam process environments produced from high-enthalpy hypersaline brine from geothermal well Magmamax No. 1 at the Salton Sea Known Geothermal Resources Area, Imperial Valley, Calif. Cadmium (and by extension cadmium coatings) and a 6061-T6 aluminum alloy were unsatisfactory because of high general corrosion rates and, in the case of aluminum, severe pitting. Molybdenum and niobium (columbium) were resistant to general corrosion, pitting, and crevice corrosion. Copper alloys corroded at rates that may preclude their use in wellhead brine. The presence of iron accelerated the corrosion of the copper alloys. Titanium alloys were resistant to general corrosion and stress corrosion cracking in all of the environments. They exhibited crevice corrosion in some of the brine and steam environments and Ti6Al4V pitted in the brine environments. They exhibited passive behavior over a broad range of potentials. Exposure tests were conducted on a high-temperature polyphenylene sulfide thermoplastic (Ryton) in the same environments. A 40-pct-graphite-fiber-reinforced Ryton composite deteriorated readily in wellhead brine and failed in all of the brine and steam process environments; Ryton coatings on 316L stainless steel were adherent and performed well.

RI 8793. The Generation, Collection, and Analysis of Welding Fumes, by J. F. McIlwain and L. A. Neumeier. 1983. 14 pp. 6 figs. The Bureau of Mines investigated fumes generated by selected welding materials used in mines in order to help determine their relative hazard potential. The initial phases of the study have been completed. A welding-fume generation and collection apparatus was designed, assembled, and calibrated. Five brands of coated, AWS-type E308-16 stainless steel electrodes were tested. Total fume generation rates of 0.39 to 0.51 g/min were measured. Quantitative chemical analyses were conducted for all of the

principal fume constituents. Two analytical schemes were used to determine levels of the Cr^{6+} and Cr^{3+} species contained in the welding fumes; comparable results were obtained. The Cr^{6+} was found to be the most hazardous constituent, leading to a maximum allowable total fume exposure of 1 mg/m³. Fume generation rates and fume constituent analyses will be derived for other groups of welding electrodes using similar procedures.

RI 8794. A Ball-on-Block Impact-Spalling Wear Test and Results on Several Iron Alloys, by R. Blickensderfer and B. L. Forkner. 1983. 18 pp. 10 figs. An impact wear testing machine was devised by the Bureau of Mines that simulates the repeated impact conditions encountered in large milling and grinding operations where breakage and spalling are problems. The apparatus provides data on materials that may help in the design of alloys with improved resistance to deformation, spalling, and breakage. The test blocks are 2 in thick by 6 in by 8 in. Impacts are produced by dropping 3-in-diam balls weighing 4 lb from a height of 10 ft. Tests were run until breakage occurred or to a total of 100,000 impacts. Four types of failures of the test block were observed: (1) cold flow of the bulk material by plastic deformation, (2) flaking of the surface in the impact region, (3) spalling of the block to form a crater in the region of impact, and (4) breakage of the test block into two or more major pieces. The effects of composition, heat treatment, microstructure, and hardness on type of failure are discussed.

RI 8795. Problems Facing Coal Mining and Gas Production in the Hartshorne Coalbeds of the Western Arkoma Basin, OK, by A. T. Iannacchione, C. A. Kertis, D. W. Houseknecht, and J. H. Perry. 1983. 25 pp. 27 figs. Major problems facing the development of coal and gas resources of the Hartshorne Coalbeds include the complex distribution of minable and unminable coal, high methane content and bed pressure, faulting, variations in degree of dip, presence of natural gas fields in associated sandstones, and legal problems, caused by local geologic characteristics, in identifying gas origin. This Bureau of Mines study provides pertinent geologic information for long-range planning of subsurface coal and gas production from the Hartshorne Coalbeds. Pittsburg, Coal, Hughes, and Atoka Counties, OK, have approximately 1 billion metric tons (1.1 billion short tons) of Hartshorne coal in place. The methane resource of Hartshorne Coalbeds is estimated at 9.2 billion m³ (325 billion ft³) and varies with overburden and rank. These estimates were compiled from gas well density logs, coal-core data, outcrop measurements, abandoned mine maps, and the literature. The Hartshorne Coalbeds represent a valuable coal and gas resource which at present is contributing nothing to coal and gas production. This report discusses potential problems and serves as a reference for future exploration and development work. Recognition of these potential geologically related problems prior to development of this basin will reduce hazards and allow for an economic recovery of these resources. GPO Stock No. 024-004-02118-7. \$4.75.

RI 8796. Caustic Extraction of Alumina and Soda From Dawsonite-Bearing Oil Shale, by Gene Asai, J. E. Mauser, R. L. Lincoln, and Jack L. Henry. 1983. 20 pp. 8 figs. The Bureau of Mines investigated the caustic extraction of alumina and soda from

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retorted dawsonite-bearing oil shale, as part of a program to devise technology for treating alternative domestic sources of alumina for the production of aluminum metal. Colorado oil shale yielding 13 pct oil (35 gal/ton) and containing 12 wt-pct dawsonite (representing about 4 pct extractable alumina) was retorted to obtain oil-free (spent) shale. Spent shale was leached with dilute NaOH to determine the effect of particle size, retorting temperature, leaching variables, and storage conditions on extraction of alumina and soda and dissolution of impurities. Maximum alumina and soda extractions were obtained by promptly leaching minus 28-mesh spent shale, obtained by retorting raw shale at about 500° C, with 0.5N NaOH. Under these conditions, dissolution of impurities such as Ca, Fe, Ti, and P was low. Leaching tests were made on spent shale stored for periods of up to 30 days at 0° to 42° C and at 0 to 100 pct relative humidity. These tests indicated that significant reductions in alumina extraction would occur if spent shale were stored in ambient Colorado air under naturally fluctuating temperature and humidity.

RI 8797. Examination of Effluents Generated From Processing Domestic Laterites, by Laurel A. Powers and R. E. Siemens. 1983. 13 pp. 5 figs. The Bureau of Mines process for recovering Ni and Co from low-grade domestic laterites uses a reduction roast followed by an ammonia, ammonium sulfate leach. This investigation examined the waste streams of the process for their potential environmental impact and focused on the laterite residue produced. The U.S. Environmental Protection Agency's extraction procedure (EP) toxicity tests and column leaching showed that leachable metal concentrations would be low enough so that the residue would not be considered a hazardous waste under present definitions. Under nonacid leaching conditions, about the same amount of metal was extracted from laterites as from their residues, and the leachates were similar to water samples from an undisturbed laterite deposit. Washing tests on the laterite residue showed that ammonia and ammonium sulfate concentrations were reduced according to equilibrium stage calculations, resulting in residues that would be acceptable for revegetation. With water washing only, the residue would not be considered a hazardous waste even though significant amounts of Ni and Co were absorbed from entrained leach solution onto the residue. Washing first with fresh leach solution and then with water prevented this absorption and thus improved the overall metal recovery.

RI 8798. Thermal and Electrical Ignitability of Dust Clouds, by Ronald S. Conti, Kenneth L. Cashdollar, Martin Hertzberg, and Israel Liebman. 1983. 40 pp. 45 figs. The Bureau of Mines conducted a comprehensive laboratory study of the thermal ignitability of various carbonaceous dust clouds with particular emphasis on various ranks of coal dust. The tests were conducted using a new 1.2-L furnace. Autoignition temperatures of dust clouds were obtained as a function of coal volatility and particle size. Dust particles and gas samples were collected by a rapid-sampling system in order to study the reactions involved in preignition and postignition processes. The autoignition temperatures measured in the new 1.2-L furnace were significantly lower and therefore more conservative than those measured previously in the Godbert-Greenwald furnace. The combined effects of thermal and electrical ig-

nitiation of dust clouds were also studied in the 1.2-L furnace using electrical discharges of varying energies at ambient and elevated temperatures. The minimum spark energy necessary to ignite a dust cloud decreased significantly as the temperature of the dust cloud increased.

RI 8799. Problems in the Control of Anthracite Mine Fires: A Case Study of the Centralia Mine Fire (August 1980), by Robert F. Chaiken, Robert J. Brennan, Bernice S. Heisey, Ann G. Kim, Wilbert T. Malenka, and John T. Schimmel. 1983. 93 pp. 54 figs. The Bureau of Mines has conducted a study of mine fires in the anthracite region of Pennsylvania to determine the most effective approaches to fire control in this area. The problems involved in controlling an anthracite fire include the geological and mining conditions in this area, the propagation characteristics of anthracite, the fire control methods available, the hazards associated with these fires, and the marginal effectiveness of past fire control projects. From this general background, fire control options were discussed as they apply in 1980 to the Centralia mine fire. Probable effectiveness, feasibility, and costs were assessed. The options evaluated include four excavation plans, flooding, hydraulic flushing, water curtain isolation, mining to construct an underground barrier, burn-out control, and relocation of the community. The most advantageous from a technical viewpoint is an excavation method combining complete excavation of the fire zone within the borough with trenching to confine the remaining fire. It appears that for many anthracite fires, as for the Centralia mine fire, there are no available control measures that have a moderate cost, are proven effective, and produce minimal disruption on the surface.

RI 8800. Coal-Cutting Forces and Primary Dust Generation Using Radial Gage Cutters, by Wallace W. Roepke and Jon I. Voltz. 1983. 24 pp. 10 figs. The Bureau of Mines determined coal-cutting forces and primary dust generation of four styles of radial gage bits as used on end rings of continuous mining machines. Direct comparisons for reference were made with two widely used conical plumb-bob types having 60° and 90° (nominal) included tip angles. The cutting forces for all of the gage bits were similar to those of the 60°-tip plumb-bob bit. All bits except the RAD-3 gage bit generated similar amounts of primary total dust at shallow cutting, but during deeper cutting, the amounts varied and the gage bits produced as much as 2½ times the dust produced by the 60° bit. This seems atypical since past experience has always shown differences in dust generation at shallow cutting. The specific energy was more like that found previously with other bits, since the values were spread at shallow cutting but became nearly similar at deeper cuts. The 90° bit and the RAD-3 gage bit are not recommended for use except in extremely difficult cutting conditions where dust and forces are of secondary importance. The choice among the remaining four bits can be made on the basis of dust, energy, forces, or cost, as circumstances dictate.

RI 8801. Testing Modified Coal-Cutting Bit Designs for Reduced Energy, Dust, and Incendivity, by Wallace W. Roepke and Bruce D. Hanson. 1983. 31 pp. 15 figs. Four bit designs, two conical and two radial, were tested in coal against a 60° conical reference bit to obtain data on orthogonal cutting forces and primary respirable dust generation. One conical and one radial design were modified by the Bureau of Mines for these tests. Results were mixed: One

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radial bit used substantially lower overall cutting forces and specific energy than the other bits and was the only cutter lower on energy and most forces than the standard 60° bit. However, it generated more specific and total dust than any other bit. The four bits were also tested for incendivity, with a 90° plumb-bob bit as the reference. The frictional ignition tests were designated to simulate both trimming top rock and cutting such rock during advance on-sump. Results of these tests were also mixed. The radial bits were substantially less incendive than the reference bit and caused no ignitions in either top trimming or sump modes. Only the modified mushroom-tipped conical bit caused ignitions. Bits similar to this modified design should not be used on drum-type miners in gassy mine areas; instead, the other types of bits tested should be used to reduce ignition potential to a minimum.

RI 8802. Drag Bit Cutting Characteristics Using Sintered Diamond Inserts, by Wallace W. Roepke, Bruce D. Hanson, and Carl E. Longfellow. 1983. 30 pp. 17 figs. The Bureau of Mines tested new designs of drag bit cutters with sintered diamond inserts instead of standard tungsten carbide tips. The bits were tested for orthogonal cutting forces, primary dust generation, and incendivity, with a standard plumb-bob type conical cutter (60° included tip angle) as the reference. Preliminary wear and impact-failure testing were also done. The results were mixed. Two new designs had forces similar to those of the reference bit, but one new design had about twice the normal force. This same design had almost twice the specific energy during shallow cutting but generated an equal or slightly lower amount of primary dust than did the reference bit. Incendivity was eliminated for two radial designs. One conical design had ignition only after more than 15 impacts, but the other conical design was incendive. Impact failure occurred, but not so quickly as anticipated. Over 7,500 impacts on a sandstone face, with a total cutting distance of more than 1,981.2 m, only scuffed the leading edge of the sintered diamond cutting face but put hairline cracks in the substrate mounting pad. Additional design and testing are needed to develop an optimum cutter, but prospects look good for this material.

RI 8803. Dewatering of Talc Slurry, by Gwendolyn D. Hood, Annie G. Smelley, and Bernard J. Scheiner. 1983. 10 pp. 6 figs. The Bureau of Mines investigated techniques for dewatering slurries from talc-processing operations to improve water reclamation and produce dewatered solids suitable for disposal. Various flocculating reagents were evaluated, and a nonionic polyacrylamide was found to be most effective in a specialized flocculation dewatering technique. The flocculation dewatering method was applied in laboratory batch tests and in continuous tests using a static screen, a belt-roller device, and a clarifier-thickener laboratory unit. In continuous tests using the unit, wastes of 3.5 pct solids were dewatered to 56.9 pct solids using 0.03 lb of flocculant per ton of dry solids treated. Research at the Tuscaloosa Research Center is carried out under a memorandum of agreement between the U.S. Department of the Interior and the University of Alabama.

RI 8804. Concrete Crib Design and Field Testing, by T. W. Smelser and L. N. Henton. 1983. 41 pp. 21 figs. This Bureau of Mines report presents a

review of underground testing, test results, and design guidelines of steel-fiber-reinforced concrete (SFC) mine support (cribbing) developed at the Spokane Research Center. The objective of the work was to verify, in field applications, the performance, economics, and acceptance by the mining industry of the SFC supports and establish design guidelines for their use underground. Results indicate superior performance, favorable economics, and enthusiastic acceptance by the mining industry.

RI 8805. Alumina Miniplant Operations—Separation of Aluminum Chloride Liquor From Leach Residue Solids by Classification and Thickening, by Roy T. Sorensen, Dwight L. Sawyer, Jr., and Theodore L. Turner. 1983. 23 pp. 19 figs. The Bureau of Mines has investigated the recovery of cell-grade alumina by HCl leaching of calcined kaolin in the alumina miniplant at its Boulder City (NV) Engineering Laboratory. Classification and thickening were used for separating aluminum chloride leach liquor from the siliceous residue generated in the acid leaching step of the clay-HCl process. Coarse solids were classified from fines at 115 mesh and countercurrently washed in three additional spiral classifiers. Fines were treated in a conventional five-thickener, countercurrent decantation circuit. When this method was applied to the solids-liquid separation of slurry from HCl leaching of minus 10-mesh calcined kaolin, 75 pct of the residue reported as classifier sands and 25 pct as thickener underflow. Predicted individual classifier and thickener area requirements were 6 and 25 ft²/tpd, respectively. Total thickener circuit flocculant requirement was 2.4 lb/ton solids. Aluminum chloride pregnant liquor was produced that analyzed 8.4 pct Al₂O₃, and contained more than 97 pct of the alumina in the liquid phase of the slurry. Bench-scale settling tests were used to correlate fines content of leach residue to thickener area and flocculant requirements.

RI 8806. Recovery of Alumina From Anorthosite by an HCl-F-Gas Sparging Crystallization Process, by J. A. Eisele and D. J. Bauer. 1983. 11 pp. 4 figs. The Bureau of Mines is investigating the recovery of alumina from domestic nonbauxitic resources including anorthosite. The United States has large reserves of anorthosite, but its aluminum content is less than 50 pct soluble in acid, unless a source of fluoride is added to the acid. A flowsheet that includes leaching with HCl and fluoride followed by crystallization of AlCl₃·6H₂O from the pregnant liquor by HCl gas injection was designed. Approximately 90 pct of the aluminum values were recovered from the anorthosite when a ratio of 0.14 mole of fluorine per mole of aluminum was used. Sodium chloride is cocrystallized with the AlCl₃·6H₂O but is removed by water washing of the Al₂O₃ product. A material balance is given based on results of laboratory studies of the unit operations.

RI 8807. Corrosion Resistance of Ceramic Materials to Hydrochloric Acid, by James P. Bennett. 1983. 14 pp. 4 figs. To identify construction materials for emerging technology in chemical and metallurgical processes, the Bureau of Mines investigated the acid resistance of ceramic materials. Eight commercial ceramic materials comprising two red shale, two fire clay, a silica, a five-clay-bonded silicon carbide, a carbon, and a high-alumina brick were evaluated. Samples were exposed for 110 days to 20 wt pct HCl at 50°, 70°, and 90° C and to 30 wt pct HCl at 70° C. Statistically significant changes in

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cold crushing strength, volume, and weight were generally small or not detected. The leach rates of Al, Ca, Fe, K, Mg, Na, Si, and Ti ions were monitored. The carbon brick sample had the best acid-resistant properties with a maximum total leached ion weight loss of 0.004 wt pct. The silicon carbide, the silica, and one of the fire clay bricks also had excellent acid-resistant properties. Research at the Tuscaloosa Research Center is carried out under a memorandum of agreement between the Bureau of Mines, U.S. Department of the Interior, and the University of Alabama.

RI 8808. Use of Foam for Dust Control in Minerals Processing, by Jon C. Volkwein, Andrew B. Cecala, and Edward D. Thimons. 1983. 11 pp. 7 figs. The Bureau of Mines conducted a series of tests to evaluate the effectiveness of mixing a compressed-air-generated foam with dried whole-grain silica sand to suppress dust in minerals processing plants. Dust at downstream transfer points was monitored with personal gravimetric samplers and with Real-Time Aerosol Monitors that were connected to strip chart recorders. Results showed dust reductions of 80 to 90 pct on three separate occasions at two different plants. The mechanism by which foam suppresses dust is discussed, as are the constraints on the use of foam, which may include incompatibility of the foam with the mineral product, difficulty in controlling the foam generator, and cost.

RI 8809. Electrochemical Determination of Thermodynamic Properties of Manganese Sulfate and Cadmium Oxysulfate, by Seth C. Schaefer. 1983. 20 pp. 7 figs. The Bureau of Mines investigated thermodynamic properties of $MnSO_4$ and $2CdO \cdot CdSO_4$ to obtain basic thermodynamic data applicable to the treatment of mineral concentrates during roasting and sintering processes. Standard Gibbs energies of formation were determined with high-temperature galvanic cells using stabilized ZrO_2 as the electrolyte.

RI 8810. Magnetic Properties of Synthetic Mischmetal Alloyed With Cobalt, Copper, Iron, and Magnesium, by J. W. Walkiewicz, M. M. Wong, and E. Morrice. 1983. 14 pp. 17 figs. The Bureau of Mines investigated alloys containing lanthanum (La), praseodymium (Pr), neodymium (Nd), cobalt (Co), copper (Cu), iron (Fe), and magnesium (Mg) as possible components of a permanent magnet material utilizing a cerium-free synthetic mischmetal (M) as a substitute for scarce samarium (Sm) metal. Magnets containing M-Co-Cu-Mg and M-Co-Cu-Fe-Mg were fabricated by powder metallurgy techniques and evaluated. A synthetic mischmetal (M20) containing 20 pct La, 60 Pr, and 20 Nd yielded the best overall magnetic properties. The M20-Co-Cu-Mg alloys had energy products as high as 13.2 MGOe, remanences as high as 7.89 kG, normal coercivities as high as 6.26 kOe, and intrinsic coercivities as high as 13.4 kOe. The best value of intrinsic coercivity, 22.9 kOe, was obtained with an M-Co-Cu-Mg magnet in which the synthetic mischmetal contained 30 pct La, 50 Pr, and 20 Nd. These values compare favorably with those of the Sm-Co magnets fabricated and measured at the Bureau's Reno Research Center, which had energy product of 15.1 MGOe, remanence of 7.8 kG, normal coercivity of 7.5 kOe, and intrinsic coercivity of 27.4 kOe. Iron substitution for part of the cobalt resulted in a decrease of magnetic properties, although several percent iron

can be added before a drastic loss of magnetic properties occurs.

RI 8811. Experimental Drift Linings in a Block-Caving Operation—A Field Demonstration, by W. C. McLaughlin, L. A. Thomas, and J. L. Harasha. 1983. 32 pp. 32 figs. Under a cooperative agreement, the Bureau of Mines, Magma Copper Co., and ASARCO, Inc., tested backfilled ground support systems at two elevations in Magma's San Manuel, AZ, mine. The tests were mainly for guidance in designing the loading crosscuts of the new ASARCO Sacaton underground mine. Two-piece, wide-flange steel sets for 8- by 8-ft (2.44- by 2.44-m) and 11- by 11-ft (3.36- by 3.36-m) openings were designed. Set spacing was 3 ft (0.91 m) and 5 ft (1.52 m), respectively. After erection, the sets were lagged with various test materials. The void between the lining and the ground was backfilled with sand and pea gravel. Instruments measuring strain (used to determine changes in stress) were placed beneath the sets and in the backfill. Results indicate the backfilled sets in the smaller drift (2315 grizzly level, panels 6 and 7) of 8- by 8-ft (2.44- by 2.44-m) cross section are a viable permanent support system, lower in cost than the standard formed concrete. Results are inconclusive in 2615 grizzly level, panels 5 and 6, where wide-flange steel sets were used with 5-ft (1.52-m) long concrete gob lagging of T-design.

RI 8812. Determining Vapor Density and Gaseous Diffusion Coefficients of Sb_2S_3 Using a Modified Transpiration Apparatus, by B. W. Madsen, A. Adams, and P. A. Romans. 1983. 14 pp. 10 figs. A modified transpiration apparatus was devised by the Bureau of Mines to permit rapid and accurate measure of the vapor transport and vapor diffusion coefficients of antimony sulfide (Sb_2S_3) and other compounds at temperatures to 1,045 K. The apparatus was equipped with dual condensers and valves to switch the flow of vapor in a fraction of a second from one condenser to the other, thus allowing short-interval sampling under equilibrium conditions. Reliability of the technique was established by measuring the vapor pressure of $ZnCl_2$ as a function of temperature and comparing the results with published data. As part of an investigation of the vapor concentrations and species of accessory element sulfides associated with copper and zinc smelting, the apparatus was used to measure the rate of vapor transport and diffusion coefficients of vapor over liquid Sb_2S_3 as a function of temperature between 870 and 1,045 K. The calculated vapor density was combined with published direct measurements of vapor pressure to calculate the average molecular weight of the gaseous species. Average molecular weight of the vapor in equilibrium with Sb_2S_3 ranged from 286 to 112 g/mol over the temperature range studied.

RI 8813. Mineralogy and Liberation Characteristics of Western Mesabi Range Oxidized Taconites, by Roland L. Blake. 1983. 26 pp. 15 figs. The Bureau of Mines investigated the mineralogy, tonnage, and beneficiating characteristics of oxidized (nonmagnetic) taconite iron resources of the Western Mesabi Range as part of its program to insure adequate future domestic mineral supplies. Magnetic taconite currently provides about 95 pct of Mesabi production, but the large tonnages of oxidized taconite between the magnetic deposits will be needed to help meet future domestic demand for

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iron ore. Three bulk samples that represent large tonnages from the Western Mesabi Range were selected to determine their mineral composition and liberation by light optical microscopy and to test their beneficiating response. This report describes the mineralogy and liberation characteristics of the three samples of the Biwabik Iron Formation for 26.5 mi (42.7 km) from Keewatin to Grand Rapids, MN. (Details of response to beneficiation were reported previously.) The samples represent mostly material from the Lower Cherty Member of the Biwabik Iron Formation, although one sample included some Upper Cherty Member. Minerals of all three samples were quartz (chert), hematite, goethite, and minor to trace amounts of magnetite, iron carbonate, and iron silicates. It was concluded that the oxidized taconites of the Western Mesabi Range represent a subeconomic indicated resource that can be selectively mined and beneficiated as a future large source of iron feed for steelmaking.

RI 8814. Factors Affecting the Dissolution of Gypsum-Bonded Roof Bolts, by S. J. Gerdemann and J. S. Hansen. 1983. 12 pp. 19 figs. In support of its objective to improve mine safety, the Bureau of Mines has searched for better materials and systems to anchor roof bolts. This report describes a study on the effects of mine waters upon accelerated gypsum, one of the materials under consideration. The accelerated gypsum dissolved at an appreciable rate relative to an assumed 10-yr life span of a roof bolt. Surface orientation, initial ion concentration of a dissolving solution, and flow rate of the solution had substantial effects on the dissolution rate. Factors such as water-cement ratio, accelerator content, wax capsule additions to the gypsum in cart-ridge-installed bolts, surface area, temperature, and curing duration had little effect. In an actual roof-bolt environment, dissolution will occur in static solutions to the solubility limit of gypsum (~2 g/L) and cease, resulting in minimal damage; but in flows of unsaturated solution as slow as 1 L per month, a loss of up to 10 pct will occur in 2 yr. Since miners cannot readily measure the flow or ion concentration of static-appearing water at every roof-bolt site, all such water must be assumed to be pure and flowing. It is recommended that gypsum-bonded roof bolts be confined to dry roofs only.

RI 8815. Laboratory Tests for Selecting Wetting Agents for Coal Dust Control, by H. William Zeller. 1983. 21 pp. 12 figs. The Bureau of Mines is conducting research to determine whether the use of chemical surfactants improves respirable coal dust control and is evaluating laboratory test criteria for selecting effective surfactants. This publication presents the results from wetting effectiveness tests with emphasis on the capillary rise test. The test variables investigated included coal particle size, type of surfactant, surfactant concentration, test duration, and mineral content of the water. In addition to the rise test, measurements of contact angle, zeta potential, and sink time for various coal and surfactant combinations were conducted. No significant correlations among the four wetting tests were observed, a surprising result which implies that each test type measures specific aspects of the wetting phenomenon and also that each test type should only be used to select surfactants for specific applications. For example, the rise test shows solution penetration into porous materials, and the sink test discriminates among surfactants for dispersing finely ground materials into suspension. Another important conclusion is that combinations of agents

retain their individual wetting properties, allowing mixtures to be formulated to perform well in both rise and sink tests.

RI 8816. Application of Inorganic Ion Exchangers to Metallurgy, by D. E. Shanks, E. G. Noble, A. M. Pierzchala, and D. J. Bauer. 1983. 19 pp. 1 fig. The Bureau of Mines surveyed a variety of inorganic ion-exchange materials to determine their suitability for removing valuable accessory elements and troublesome contaminants from metallurgical process and waste streams. Most of the materials, which included molecular sieves, heteropolyacid salts, and hydrous metal oxides, did not give adequate separations, did not have the necessary stability in strong acids or bases, or were not in a physical form suitable for ion-exchange use. Many of the suitable inorganic materials, especially the hydrous oxides, were capable of cation exchange with high capacity only in basic conditions, which caused hydrolysis of most of the cations tested. Multivalent anions, such as arsenate and phosphate, were easily removed from acidic solutions by hydrous oxides. Hydrous zirconia was the best material for this purpose. Multivalent anions were not easily desorbed because of compound formation; therefore, conventional ion-exchange techniques could not be employed. As an alternative approach, hydrous ferric hydroxide was used as a filter material to remove arsenate and phosphate from acid solutions. One gram of arsenic was removed from solution for each 20 g of ferric hydroxide. Ferric hydroxide is preferable to hydrous zirconia for use as a filter material because of low cost.

RI 8817. An Analysis of 6X19 Classification Wire Hoist Rope, by R. R. Lowery and G. L. Anderson. 1983. 33 pp. 11 figs. An analysis of three 1¼-in-diam manufactured wire ropes of 6x19 classification was done to identify and describe reference conditions of new rope. Reference condition is of value when examining tested or retired ropes. Measurements of strand and rope pitch and of wire and rope diameter confirmed adherence of all ropes to those construction specifications. Mechanical properties of strength and ductility were determined by accepted methods for the ropes and wires from the ropes. Individual wires from one rope failed to meet minimum wire ductility values. Wire chemical composition varied in average carbon levels, from 0.70 to 0.78 wt pct, and in manganese content, from 0.45 to 0.80 wt pct. One manufacturer's product contained 1 to 3 wt pct Ni and Cr. Heavily wrought pearlitic steel microstructures were porous and contained inclusions. Cold work variations were evidenced by wrought grain width. Recorded anomalies reflected the condition of the manufactured products. The report provides data that compare the three wire ropes studied, but cannot verify the effects that these conditions or anomalies have on rope service life.

RI 8818. Surface Evaluation of the 4M Miniminer System, by August J. Kwitowski. 1983. 71 pp. 63 figs. This report presents the results of a joint Bureau of Mines-U.S. Department of Energy project that evaluated a newly developed low-coal mining system: the 4M miniminer system. The evaluation took place from April through October 1981 and determined potential health, safety, and productivity factors for the mining system using the surface test facilities at Bruceton, PA. The planning, testing, results of testing, and a summary evaluation of the 4M miniminer system are included in the report. The miniminer system was found to be a very good

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concept with future potential for safe, healthful, and economic production in thin-seam mining. The mining system was also judged to have considerable potential for use in some coal seams that are presently considered unminable by other existing mining equipment. The preproduction, prototype version of the miniminer system that was tested suffered from several safety and production problems. These problems are also described, along with suggested remedies.

RI 8819. Flocculation of Sulfide Mineral Fines by Insoluble Cross-Linked Starch Xanthate, by S. C. Termes, R. L. Wilfong, and P. E. Richardson. 1983. 23 pp. 26 figs. The Bureau of Mines conducted research on the flocculation of various minerals with insoluble cross-linked starch xanthate (ISX) to determine its potential as a beneficiation technique for low-grade, highly disseminated ores and for selective desliming. Covellite, chalcocite, pyrite, pyrrhotite, chalcopyrite, bornite, sphalerite, galena, and molybdenite fines flocculate with ISX. Floc formation, floc size, and settling rate are dependent on pH, with the pH dependence differing for each mineral. Quartz is not flocculated by ISX. Experiments to obtain selective flocculation of sulfides from quartz were attempted. Good selectivity was only obtained for the bornite-quartz system. Postflocculation separations resulted in flocculated bornite in grades as high as 92 pct. Evidence is presented that the flocculation of many of the sulfide minerals with ISX may involve covalent bonding of the xanthate group to lattice metal site(s).

RI 8820. Cutting Parameters Affecting the Ignition Potential of Conical Bits, by Bruce D. Hanson. 1983. 14 pp. 4 figs. The Bureau of Mines conducted a series of ignition tests with two types of conical bits (plumb bob and pencil) used on continuous mining machines, to determine their ignition potential at various bit speeds, cut depths, and wear conditions. The tests were conducted using single bits mounted on a 34-in-diam drum in a Bureau ignition test facility. The bits impacted blocks of Berea sandstone in a 6.5 pct methane atmosphere at various bit speeds and cut depths. In a new condition, the plumb-bob bits were considerably more incendive than the pencil bits, causing ignitions in 32 of 35 tests at 60 rpm, compared with ignitions in 2 of 22 tests for the pencil bits. The results from new bit testing also show that reduction of bit tip velocity to 180 fpm does not eliminate ignition potential. When subjected to progressive wear, bits of both types were more incendive when they were locked in place, unable to rotate, than when they were free to rotate.

RI 8821. Shaft Furnace Reduction-Oxidation Roasting of Pelletized Alunite Dust, by J. M. Riley, V. E. Edlund, and W. I. Nissen. 1983. 21 pp. 8 figs. The Bureau of Mines investigated a promising new technology for recovering Al_2O_3 from alunite to support the Bureau's alumina miniplant project. Results are presented for a study of the technical feasibility of treating alunite crushing and grinding reject fines for recovery of Al_2O_3 . Alunite pellets having sufficient strength and resistance to degradation were produced by combining fines and coarse alunite with a KOH binder. The best pellets were prepared, in a laboratory pelletizer, by adding 1 pct KOH as a 5-pct solution to a mixture of 40 pct alunite dust (98 pct minus 65 mesh) and 60 pct coarse alunite (minus 20 plus 65 mesh). Calcines suitable for K_2SO_4 and Al_2O_3 recovery were produced

by reducing dehydrated alunite pellets with sulfur in a laboratory shaft furnace for 4 h at 600° C, followed by air oxidation of the reduced calcine for 1 h at 600° C. This report presents design calculations, schematic diagrams, and discussions of the essential features of a proposed process research unit—a continuous, 6-lb/h alunite shaft furnace—for studying the process.

RI 8822. Vanadium-Uranium Extraction From Wyoming Vanadiferous Silicates, by M. Hayashi, I. L. Nichols, and J. L. Huiatt. 1983. 9 pp. 2 figs. The Bureau of Mines conducted laboratory studies on low-grade vanadiferous silicates from the Pumpkin Buttes and Nine Mile Lake deposits of Wyoming to examine techniques for extracting vanadium and uranium. Recovery from low-grade sources such as these could contribute to future vanadium production and reduce reliance on vanadium imports. The Pumpkin Buttes samples contained 0.03 to 0.04 pct V_2O_5 and 0.06 to 0.12 pct U_3O_8 ; the Nine Mile Lake samples contained 0.02 to 1.0 pct V_2O_5 and 0.06 to 0.19 pct U_3O_8 . Leaching the Pumpkin Buttes samples for 18 h at 80° C with addition of 200 lb/ton H_2SO_4 resulted in recovery of 80 pct of the vanadium contained in the samples. The Nine Mile Lake samples were readily leached, yielding 78 to 94 pct of the vanadium after 3 h at 80° C with addition of 100 lb/ton H_2SO_4 . A solvent extraction procedure was used to selectively recover uranium from Pumpkin Buttes and Nine Mile Lake leach solutions and to recover vanadium from the raffinate. In batch shakeout tests, Alamine 336 recovered over 95 pct of the uranium from leach solution adjusted to pH 1. Di-2-ethylhexyl phosphoric acid and Cyanex 272 recovered vanadium from the uranium raffinate after reduction and adjustment to pH 2; vanadium extractions of up to 96 pct and 92 pct, respectively, were achieved.

RI 8823. Resistance of Selected Refractories to Mineral Waste Melts, by Timothy A. Clancy. 1983. 13 pp. 11 figs. In support of research on forming ceramics from mining and processing wastes, the Bureau of Mines tested various commercial refractories to evaluate their resistance to melts of these wastes. Sixteen refractories of various types were exposed in slag erosion tests to two siliceous waste melts with SiO_2/CaO ratios of 4.0 and 2.2. The extent and nature of slag attack were then determined for each refractory. The nature of slag attack was investigated through scanning electron micrographs and microprobe elemental distributions. The refractories that performed best in resisting attack by the melts were high-alumina types, and of the refractories tested, the most resistant was a 90-pct- Al_2O_3 , 10-pct- Cr_2O_3 refractory. Research at the Tuscaloosa Research Center is carried out under a memorandum of agreement between the Bureau of Mines, U.S. Department of the Interior, and the University of Alabama.

RI 8824. Dewatering of Coal-Clay Waste Slurries From Preparation Plants, by P. M. Brown and B. J. Scheiner. 1983. 8 pp. 3 figs. The Bureau of Mines is investigating a dewatering technique for coal-clay waste that uses a flocculant, polyethylene oxide (PEO). This flocculant forms strong stable flocs that can be dewatered on a static screen. A field test unit (FTU) using this technique was operated at approximately 400 gal/min, using a waste stream from the flotation circuit of a coal preparation plant. Consolidated coal-clay material containing 55 to 60 pct solids was produced when

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the flotation circuit slurries of 2.7 to 8 pct solids were treated with 0.1 to 0.3 lb PEO per ton of solids. The FTU was also operated at 64.5 and 87.5 gal/min using a portion of the underflow slurry from the preparation plant's thickener. Consolidated coal-clay material containing 55 to 60 pct solids was produced when the thickener underflow slurries of 19 to 24 pct solids were treated with 0.08 to 0.2 lb PEO per ton of solids. PEO-treated materials continued to dewater when placed in a pit. Research at the Tuscaloosa Research Center is carried out under a memorandum of agreement between the Bureau of Mines, U.S. Department of the Interior, and the University of Alabama.

RI 8825. Slurry Transport Properties of Graded Coal Waste, by R. W. McKibbin, R. R. Backer, and R. A. Busch. 1983. 26 pp. 16 figs. The Bureau of Mines conducted laboratory tests to determine the slurry transport and deposition properties of coal waste. A 188.5-ft pipe test loop was constructed with instruments to measure density, flow, and power and discharge, suction, and differential pressures. A 20-ton sample of Western coal waste was crushed and screened to 100 pct minus $\frac{1}{2}$ in. Eight loop tests using this graded waste were run at slurry densities ranging from 1.15 (25 wt-pct solids) to 1.46 (60 wt-pct solids). The resultant friction-pressure gradients ranged from 0.06 to 0.24 ft of water per foot of 4-in standard steel pipe. Particle-size degradation was significant. In a typical loop test lasting 25 min, the minus 200-mesh fraction increased from 19 pct to 34 pct. Deposition tests showed that without the use of a flocculant, the slurries would not dewater when left to stand for 1 week. With flocculant, additional water was released; however, the settled slurries remained thixotropic. Further testing is necessary to determine their suitability for use as backfill material in active mines.

RI 8826. Neodecanoic Acid as a Co^{2+} Solvent Extractant, by L. R. Penner, Davis E. Traut, and Jack L. Henry. 1983. 10 pp. 3 figs. The Bureau of Mines conducted solvent extraction batch tests to evaluate the usefulness of neodecanoic acid (NDA) for extracting Co^{2+} from ammoniacal leach liquors high in ammonium sulfate. This work is an outgrowth of previous Bureau research in which technology was devised for the recovery of cobalt, nickel, and byproduct copper from domestic laterites. The previously devised technology uses an oxidative ammoniacal sulfate leach to treat the laterite, and nickel and copper are then recovered from the leach solution by solvent extraction and electrowinning. This report deals with the subsequent solvent extraction of cobalt from the nickel-copper raffinate solution. The results showed that about 70 pct of the contained Co^{2+} can be extracted batchwise at pH 8 using NDA (a 10-carbon-chain highly branched carboxylic acid). However, NDA had a solubility of approximately 0.6 to 0.8 g/L in aqueous raffinate following extraction, and this high solubility makes it impractical for use with alkaline solutions that are low in cobalt. In addition, the extracted cobalt species (predominantly cobaltic hexammine), is not amenable to the electrolytic recovery of cobalt metal because of its extreme stability. This fundamental problem, common to all extractants of the cobaltic amines, is discussed, and an alternative for recovering cobalt metal from loaded solvent by a hydrogen-reduction method is also discussed.

RI 8827. Percolation Leaching of a Chalcopyrite-Bearing Ore at Ambient and Elevated Temperatures With Bacteria, by B. W. Madsen and R. D. Groves. 1983. 14 pp. 11 figs. The Bureau of Mines conducted a large-scale (6.4 t), long-term (2,165 days) test to gain a better understanding of the leaching characteristics of chalcopyritic ores. An ore sample containing 0.77 pct Cu was leached in a fiberglass column by downward percolation of acidified ferric sulfate solutions. Three sets of leaching conditions were investigated: (1) ambient temperature leaching, (2) elevated temperature (50° to 60° C) leaching, and (3) elevated temperature leaching after inoculation with thermophilic bacteria. Leaching at ambient temperature resulted in a copper extraction rate of 0.44 pct per 100 days. Increasing the temperature to 50° to 60° C resulted in decreased activity of natural mesophilic bacteria, and the leaching rate decreased to 0.22 pct per 100 days. The pH was lowered from 2.0 to 1.6, and nutrient solutions that contained thermophilic bacteria were added. This procedure resulted in an increase in the ferric-to-ferrous iron ratio and an increase in the copper leaching rate. However, the increased leaching rate was not sustained, and 120 days after inoculation, the bacterial activity declined, the ferrous iron content increased, and the copper leaching rate decreased.

RI 8828. Vertical Magnetic Noise in the Voice Frequency Band Within and Above Coal Mines, by John Durkin. 1983. 27 pp. 14 figs. Information on vertical magnetic noise in the voice frequency band, both within and above coal mines, is needed for the evaluation of through-the-earth baseband electromagnetic communications at mines where horizontal loop antennas are used. This report discusses the theory of the source of electromagnetic noise, the propagation of this noise to an observation point above a mine, and its interaction with the local earth conductivity structure, which gives rise to vertical magnetic noise. The relationship of surface noise to underground noise is also discussed. Bureau of Mines investigators made surface and underground vertical magnetic noise measurements at a number of coal mines located throughout the United States. These data were modeled through regression analysis to characterize expected noise levels. The results are presented, including results in one-third octaves for use in evaluating the expected performance of through-the-earth communication systems by articulation-index studies.

RI 8829. Structure and Porosity of Electrodeposited Platinum: Evaluation of Four Plating Methods, by M. J. Lynch, R. P. Walters, and D. R. Flinn. 1983. 18 pp. 7 figs. The Bureau of Mines evaluated the feasibility of substituting platinum-coated metals for bulk platinum shapes as a means for conserving platinum. Platinum coatings were prepared using four different methods of electrodeposition, then tested and evaluated. In order for platinum coatings to be useful in process environments, they must be thick, adherent, stress-free, and pore-free. The Bureau evaluated direct-current, current reversal, cathode shielding, and pulsed-current plating techniques for producing a pore-free platinum electrodeposit from a molten cyanide bath. Aqueous corrosion tests of Fe-10Cr substrates coated with approximately 25 μm of platinum showed that pulse plating yielded the most corrosion-resistant and, hence, the most pore-free coatings. The morphology of coating cross sections was in all cases columnar. The average

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grain size of pulse-plated deposits was independent of thickness, while all other plating techniques produced grains that increased in size as the coatings became thicker. It is believed that the constant grain size in the pulse-plated deposits resulted from better mass transport during the electrodeposition.

RI 8830. Alumina Miniplant Operations—Evaporative Crystallization of Aluminum Nitrate Nonahydrate From Aluminum Nitrate Solutions, by T. L. Turner and Daniel T. Rogers. 1983. 29 pp. 8 figs. As part of a program to investigate technology for the extraction of alumina from abundant domestic ores, the Bureau of Mines studied HNO₃ leaching of calcined Georgia kaolinitic clay. In this investigation, iron impurities were removed from the aluminum nitrate pregnant leach liquor by solvent extraction, and the purified liquor was evaporated to prepare a suitably concentrated crystallizer feed liquor. Aluminum nitrate nonahydrate was crystallized from the liquor to separate the aluminum from undesirable trace elements and excess water. Continuous crystallization at 40° C in a pilot plant vacuum evaporative unit was performed for 5 days to observe the effects of impurity buildup under minimum bleed-stream conditions. Liquor feed rate was 26 lb/h and Al(NO₃)₃·9H₂O (ANN) crystal production rate was 17 lb/h. Fe₂O₃ and Cr₂O₃ were not effectively separated from the crystals, and P₂O₅, MgO, and K₂O impurities must be removed by recrystallization. Other impurities did not excessively contaminate the crystals. Washing the crystals with water or aqueous HNO₃ gave an equivalent increase in crystal purity levels by displacing mother liquor. Theoretical equations, applicable to any continuous evaporative crystallization of ANN, were developed to produce material balances for engineering applications.

RI 8832. Lime-Gypsum Processing of McDermitt Clay for Lithium Recovery, by V. E. Edlund. 1983. 15 pp. 5 figs. As part of its efforts to devise new and improved methods for recovering lithium from unconventional resources, the Bureau of Mines investigated a lime-gypsum-roast, water-leach technique for processing lithium-enriched (0.01–0.68 pct Li) clays. This report presents the results of a study of the technical feasibility of extracting lithium from raw material representative of clay beds associated with the McDermitt Caldera complex in Nevada and Oregon. Pellets suitable for bench-scale roasting studies were prepared from mixtures of minus 200-mesh clay, limestone, and gypsum, with water used as the pelletizing agent. Roasting pelletized charges at 900° to 1,000° C temperatures for 1- to 4-h periods produced calcines that leached readily, yielding water-soluble lithium sulfate (Li₂SO₄). A 5–3–3 (weight ratio) mix of clay, limestone, and gypsum produced calcines with the best leaching characteristics. More than 91 pct of the contained lithium was extracted from pelletized mix batches roasted in covered refractory boats. Lithium recovery decreased to about 87 pct when the mix was roasted under dynamic conditions in a gas-fired rotary furnace. A reaction mechanism was postulated which indicated that dilution and loss of SO₂ and oxygen in the combustion exhaust adversely affected the leachability of the dynamically roasted calcine.

RI 8833. Increasing the Leaching Rate of Bulk Superalloy Scrap by Melting With Aluminum, by G. B. Atkinson. 1983. 11 pp. 10 figs. The Bureau of Mines investigated a method for increasing the leaching rate of bulk superalloy scrap to facilitate

recycling and recovery of critical metals such as Ni, Co, and Cr. Three superalloys were investigated, the cast-nickel-base superalloy IN-738, the wrought-nickel-base superalloy Rene-41, and the cast-cobalt-base superalloy Mar-M-509. Superalloys melted with 20, 30, 40, and 50 pct Al metal to form intermetallic compounds were easily crushed to a convenient particle size and reacted rapidly with acid solutions which dissolved the metals. For example, leaching ½-in pieces of unalloyed IN-738 with excess 6N HCl at 95° C for 2 h dissolved about 0.5 pct, while leaching 10 g of minus 20-mesh 30 pct Al-70 pct IN-738 with excess 6N HCl at 95° C for 2 h dissolved 96.2 pct.

RI 8834. Leaching Aluminum From Calcined Kaolinitic Clay With Nitric Acid, by Richard S. Olsen, William G. Gruzensky, Sophie J. Bullard, R. P. Beyer, and Jack L. Henry. 1983. 14 pp. 3 figs. Prior work by the Bureau of Mines demonstrated a feed preparation method that eliminates the formation of slime during leaching of calcined kaolinitic clay and makes leached residues fast settling and easy to filter. Nitric acid leaching rates determined for calcined kaolinitic clay prepared by this method were found to correspond to a zero-order reaction model for both batch and continuous, stirred-tank leaching. A rate constant of 0.0136 min⁻¹ was determined. Separation of solid residues from the reacted slurry was examined, and filtration rates were determined. Permeabilities of the flocculated, leached residues were around 51 darcys, or 5.0 × 10⁻⁷ cm² for laminar flow through 4-ft-deep beds.

RI 8835. Characterization of Lateritic Nickel Ores by Electron-Optical and X-Ray Techniques, by D. Chandra, C. O. Ruud, and R. E. Siemens. 1983. 12 pp. 4 figs. The mineralogical constitution of a lateritic ore dictates the type of metallurgical process that can be used to extract valuable metals such as nickel and cobalt. To provide needed mineralogical information on the interrelationships of the metals contained in domestic laterites, the Bureau of Mines awarded a grant to Denver Research Institute to study the transition-type, low-grade laterites found in northern California and southern Oregon. For comparison, limonitic-type laterites from New Caledonia and the Philippines were also studied. X-ray diffraction, electron microscopy, electron beam analysis, and conventional petrography were used to determine the mineralogical associations of nickel and cobalt in the laterites. Results showed that for both laterite types studied most of the nickel and minor amounts of cobalt are associated with the mineral goethite (FeO(OH)). Most of the cobalt and minor amounts of nickel are associated with a mixed manganese oxide (wad) mineral.

RI 8836. Removal of Cyanide and Metals From Mineral Processing Waste Waters, by Joseph E. Schiller. 1983. 8 pp. The Bureau of Mines is investigating methods to treat waste water that contains cyanide. This report describes a new method that removes heavy metals and all forms of cyanide. In the first step, hydrogen peroxide and sodium thiosulfate are added at pH 7 to 9 in a 1:2 molar ratio to convert free and weakly complexed cyanide to nontoxic thiocyanate. Then steryldimethylbenzylammonium chloride is added to precipitate ferrocyanide, and finally, ferric sulfate is added as a sweep floc and sequestrant for heavy metals. After the suspended solids settle, the water is polished by filtering. The water initially contained 1 to 5 mg/L Fe, 1 to 5 mg/L Cu,

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and 10 to 30 mg/L total cyanide; the level of each of these constituents was reduced to less than 0.02 mg/L.

RI 8838. Water Infusion—An Effective and Economical Longwall Dust Control, by Joseph Cervik, Albert Sainato, and Eugene Baker. 1983. 14 pp. 9 figs. In Europe, water infusion is used widely to reduce generation of respirable dust during mining. Its use in the United States is limited to a few plow operations in the Pocahontas No. 3 Coalbed. This Bureau of Mines report describes the technology for infusing water into a longwall panel and reports the results of a recent demonstration in the Lower Sunnyside Coalbed that achieved dust reductions averaging 58 pct. Because water infusion increases moisture content of the coalbed, face air velocities in excess of 500 ft/min (2.5 m/s) are possible, further diluting dust levels before dust entrainment occurs. An economic analysis shows a 23-pct reduction in operating costs when coal production is increased by changing from unidirectional mining to bidirectional mining with water infusion.

RI 8839. Laboratory Testing of Compressed-Oxygen Self-Rescuers for Ruggedness and Reliability, by Nicholas Kyriazi, John Kovac, Wayne Duerr, and John Shubilla. 1983. 17 pp. 13 figs. The Bureau of Mines subjected three commercial compressed-oxygen self-contained self-rescuers to a series of laboratory treatments designed to simulate various environmental conditions in underground coal mines. The environmental treatments consisted of extremes of temperature and of shock and vibration. The tests were designed to predict the ability of the self-rescuers to withstand those environmental stresses without causing a decrease in wearer protection. A critical concern was internal damage to an apparatus that would cause it to malfunction or seriously degrade its performance without any obvious external signs. The Bureau has previously tested chemical oxygen self-contained self-rescuers in a similar research program. Although the three compressed-oxygen units are not as sturdy as the chemical oxygen self-rescuers tested previously, they performed reliably after treatments on treadmill tests with human subjects and on machine tests using a breathing and metabolic simulator. Serious damage was caused by both the heat treatment of 71° C (venting of the O₂ bottle in most cases), and in the shock treatment (breaking open

of the case and dislodging of the components). When physical damage is obvious, a complete refurbishing of the damaged self-rescuer is recommended.

RI 8841. Control of Longwall Gob Gas With Cross-Measure Boreholes (Upper Kittanning Coalbed), by A. A. Campoli, J. Cervik, and S. J. Schatzel. 1983. 17 pp. 20 figs. The cross-measure borehole technique is being studied by the Bureau of Mines as an alternative to the use of surface gob boreholes as a means of controlling methane in gobs during longwall mining. Small-diameter holes are drilled from underground locations into strata overlying the mined coalbed. When the roof strata are fractured by the mining operation, a partial vacuum applied to the boreholes draws the methane out of the fractured strata and prevents it from entering the mine ventilation system. Tests in the Upper Kittanning Coalbed showed that 50 pct of the methane produced by the longwall mining operation was captured by the cross-measure boreholes. Borehole inclination and penetration into the gob are two important borehole parameters that affect the performance of the cross-measure borehole system.

RI 8847. Control of Acid Drainage From Coal Refuse Using Anionic Surfactants, by Robert L. P. Kleinmann and Patricia M. Erickson. 1983. 16 pp. 8 figs. To control the formation of acid drainage at its source, the Bureau of Mines has investigated the role of iron-oxidizing bacteria in the oxidation of pyrite. In laboratory tests, it was determined that *Thiobacillus ferrooxidans* could be controlled in coal refuse using anionic surfactants, with an associated decrease in acid production of about 75 pct. Based on these results, large-scale tests were conducted at an 8-acre active coal refuse area in northern West Virginia and an 11-acre inactive refuse pile in southern West Virginia. Acid production was decreased 60 to 95 pct for 4 to 5 months after application of 55 gal/acre of 30-pct sodium lauryl sulfate solution. To date, effluent surfactant concentrations have been extremely low. Either a hydroseeder or a road-watering truck can be used to apply the surfactant. Since the surfactant solution must reach the pyritic material to be effective, sites that have been reclaimed are generally not amenable to these procedures. A simple laboratory test is described that provides an estimate of adsorption potential; this can be used to calculate a safe application rate.

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IC 8909. Historical Summary of Coal Mine Explosions in the United States, 1959-81, by J. K. Richmond, G. C. Price, M. J. Sapko, and E. M. Kawenski. 1983. 53 pp. 17 figs. This Bureau of Mines publication presents investigators' reports of all major coal mine explosion disasters that occurred in the United States from 1959 through November 1981, along with a brief analysis of common factors in these disasters. The report reviews the Federal mine health and safety acts of 1969 and 1977, and discusses how implementation of these acts has reduced the number of both fatalities and disasters. Current Bureau health and safety research is summarized, and an appendix lists most of the ignitions and explosions in the period of record. GPO Stock No. 024-004-02108-0. \$4.75.

IC 8911. Lake Lynn Laboratory: Construction, Physical Description, and Capability, by Robert H. Matthes, Alex Bacho, and Lewis V. Wade. 1983. 40 pp. 55 figs. The Lake Lynn Laboratory is a multi-purpose mining research laboratory operated by the Bureau of Mines and located in Fairchance, PA. It consists of both surface and underground facilities. The initial focus of the facility, scheduled for full operation in fall 1982, will be on the problems of fires and explosions in mines. The initial experimental explosion was fired on March 3, 1982. The intent of this document is to provide the reader with detailed information on the physical capabilities of the Lake Lynn Laboratory. Subsequent publications will focus on the capabilities of Lake Lynn as compared with those of other similar facilities worldwide, and a comparison of initial explosion test results realized at Lake Lynn and comparable results from the Bruceston Experimental Mines.

IC 8912. Design Criteria for Rapid-Response Pneumatic Monitoring Systems, by Charles D. Litton. 1983. 23 pp. 8 figs. This Bureau of Mines report presents a discussion of the essential components of pneu-

matic monitoring systems and their associated functions. Design criteria are presented that can be used for the design and fabrication of pneumatic monitoring systems having total system response times on the order of 15 to 30 min. To illustrate the utility of these design criteria, two detailed design examples are presented.

IC 8913. Dolomite Refractories, and Their Potential as Substitutes for Imported Chromite, by Timothy A. Clancy. 1983. 18 pp. 9 figs. To help reduce the Nation's dependence on imported chromite, the Bureau of Mines is conducting research on the use of dolomites as an alternate material. Dolomite is a plentiful domestic resource and offers certain advantages as a refractory raw material. A review of the literature has indicated that there are many sources of high-purity dolomite in this country and that European nations use a greater proportion of dolomite refractories, primarily in steelmaking, than the United States. The Bureau of Mines characterized 14 domestic dolomites as to chemistry, density, mineralogy, microstructure, and thermal behavior, to develop baseline data on their suitability as refractory raw materials. Research at the Tuscaloosa Research Center is carried out under a cooperative agreement between the U.S. Department of the Interior, Bureau of Mines, and the University of Alabama.

IC 8914. The Florida Phosphate Industry's Technological and Environmental Problems, A Review, by Staff, Bureau of Mines, Tuscaloosa Research Center. 1983. 42 pp. 21 figs. The Florida phosphate industry currently produces more than 80 pct of the total U.S. marketable output of phosphate rock. Because phosphate is one of three principal nutrients used in formulating a complete fertilizer, it is imperative that an uninterrupted supply of this material be available to meet the agricultural requirements of the United States while maintaining a viable phosphate industry which is competitive in world markets. As a result of an evaluation made by the Bureau of Mines, five areas were identified that affect the overall production and projected growth of the phosphate industry in Florida. These areas relate to the technological ability of the industry to comply with environmental regulations and performance standards by using the best available technology. The most significant technical problem facing the industry is the management of the clay fraction rejected during the beneficiation of phosphate ores. Other areas of concern are environmental restrictions and regulatory requirements, issues associated with mining and reclamation of wetlands, reclamation of other disturbed lands, and consumptive water use. Each of these areas is reviewed, with major emphasis placed on the current state-of-the-art processes for treatment and management of phosphatic clays. Research at the Tuscaloosa Research Center is carried out under a memorandum of agreement between the U.S. Department of the Interior and the University of Alabama. GPO Stock No. 024-004-02110-1. \$4.75.

IC 8915. Podiform Chromite Occurrences in the Caribou Mountain and Lower Kanuti River Areas, Central

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Alaska. Part I: Reconnaissance Investigations, by Jeffrey Y. Foley and Mark M. McDermott. 1983. 27 pp. 24 figs. The Bureau of Mines sampled surface exposures of podiform chromite in the Caribou Mountain-Melozitna ultramafic belt in the Kokrines-Hodzana Highlands, central Alaska. Fieldwork began in 1979 as part of an assessment of the mineral potential of lands adjacent to the trans-Alaska pipeline corridor, for the Bureau of Land Management, and continued through 1981 as a Bureau of Mines investigation. The belt comprises six complexes of which the three closest to the pipeline corridor were investigated. Concentrations of chromite disseminated in dunite host rock make up mineralized intervals ranging in thickness from less than an inch to 5 ft and in grade from 3 to 23 pct chromium. The largest occurrence has an exposed strike length of 80 ft. Bulk surface samples were collected from 10 of these exposures, and beneficiation tests on the samples produced concentrates of metallurgical, refractory, and subindustrial grades. Part I—this report—describes the fieldwork; part II—IC 8916—describes the beneficiation work.

IC 8916. Podiform Chromite Occurrences in the Caribou Mountain and Lower Kanuti River Areas, Central Alaska. Part II: Beneficiation, by D. C. Dahlin, L. L. Brown, and J. J. Kinney. 1983. 15 pp. 2 figs. The Bureau of Mines has investigated podiform chromite deposits in three ultramafic bodies in the Caribou Mountain and lower Kanuti River areas of central Alaska. The investigation, reported in two parts, was done as part of the Bureau's mission to help insure an adequate supply of minerals to meet the Nation's needs. Part I describes an extensive field investigation and mineralogical studies by personnel from the Bureau's Alaska Field Operations Center. This report, part II, describes the mineralogy of 11 samples that were high-graded from surface exposures at 10 sites and presents the results of laboratory batch beneficiation tests designed to concentrate the chromite. The 11 samples, peridotites and chromitites that consisted of variable amounts of chromite or chromium-bearing spinels, olivine, and serpentine, were beneficiated by grinding and sizing, gravity concentration, and electrodynamic separation. Three high-chromium chromite concentrates, two high-iron chromite concentrates, and one high-aluminum chromite concentrate were produced. Three other concentrates were marginal, and two were submarginal. Chromium recoveries ranged from 54 to 92 pct. These results indicate that the areas may be significant chromium resources. Potential platinum association with the chromite was also investigated. Analysis of these 11 samples indicates that the areas are not good platinum resources.

IC 8917. Aluminum Availability—Market Economy Countries. A Minerals Availability Program Appraisal, by G. R. Peterson and S. J. Arbelvide. 1983. 31 pp. 10 figs. To determine the availability of aluminum from world bauxite resources, the Bureau of Mines investigated 139 bauxite deposits worldwide and evaluated the potential production of aluminum based on the demonstrated resources of bauxite ore from 91 mines and deposits in 22 market economy countries. The demonstrated resources of the bauxite mines and deposits included in this study represent an in situ resource of 20.2 billion metric tons of bauxite. Total identified bauxite resources in market economy countries amount to roughly 31.9 billion tons. Of the demonstrated resource, some 18.8 billion tons of bauxite considered minable provide a production potential of 3.6 billion tons of primary aluminum. Given the wide geographic distribution

of bauxite deposits, stable supplies of bauxite for aluminum production seem assured well into the next century. However, a tight market situation could develop during the 1990's unless the real price of aluminum increases enough to stimulate massive new investments in production capacity, particularly in refining and smelting. This study indicates that a real price of at least \$0.85 per pound (in January 1980 dollars) would be necessary to stimulate the required investments and provide a sufficient rate of return on invested capital.

IC 8918. A Guide to Geologic Features in Coal Mines in the Northern Appalachian Coal Basin, by Paul W. Jeran and Jacqueline H. Jansky. 1983. 16 pp. 22 figs. This Bureau of Mines report has been prepared to provide a means whereby mineworkers without specific geologic training can recognize and record the existence of potentially hazardous geologic features encountered in coal mines. Each geologic feature described in this report has been implicated in roof failure. Through the recording of the observations of mineworkers, based on this report, a geologic map of mine workings and the associated ground control problems can be compiled. From such maps, the trends of changes and features can be determined and projected ahead of mining. The face crew can be alerted to a potential problem and what to look for as the face is advanced.

IC 8919. Guidelines for Siting Product-of-Combustion Fire Sensors in Underground Mines, by C. D. Litton. 1983. 13 pp. 3 figs. This Bureau of Mines report presents a set of guidelines for determining the distribution of product-of-combustion fire sensors in underground mines. Sensor spacing is defined in terms of sensor alarm threshold, ventilation flow rate, and mine entry dimensions. Sensor spacing guidelines are presented for detection of fires from two primary combustibles, coal and wood, which are common to the majority of underground mines. The guidelines are based on data from full-scale and intermediate-scale fire tests conducted by the Bureau of Mines.

IC 8920. Characteristics of the OTOX Model CTL Oxygen Sensor, by J. E. Chilton, G. H. Schnakenberg, Jr., and L. Spinetti. 1983. 16 pp. 11 figs. The Bureau of Mines has examined the operation of an oxygen sensor manufactured by the City University, London, England. The sensor produces a current proportional to the oxygen concentration by reacting oxygen at a nonconsumable cathode. The sensor design is unique in that the primary mode of oxygen transport to the cathode is by diffusion through a capillary. The sensor using this design has a stability of 0- to 0.02-pct reading change per day over a 4.7-month test, small temperature coefficient of 0.29-pct reading change per degree Celsius, and small pressure coefficient of 0.34-pct reading change per 1,000-ft altitude change. If this sensor were incorporated into an oxygen detector or monitor, this would be a distinct improvement in electrochemical-type oxygen analyzers and would be useful to the mining industry.

IC 8921. Methods for Determining Sources of Mercury Vapor in the Workplace, by D. L. Neylan, H. C. Triantafyllou, and S. L. Law. 1983. 15 pp. 1 fig. The Bureau of Mines evaluated various methods for identifying sources of mercury vapor in excess of the threshold limit value (TLV) of 0.05 mg of mercury per cubic meter of air set by the American Council of Government and Industrial Hygienists (ACGIH) for mines and mineral processing plants. Chemical spot tests and portable devices for mercury

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determination were evaluated, based on information from published sources and performance in laboratory tests. Among the parameters examined were sensitivity, interferences, cost, ease of use, and other factors pertinent to field application. More than 50 methods were evaluated. The investigators found that many readily available methods are suitable for identifying sources of mercury vapor in mines and mineral processing plants. The best method appears to be one that uses a commercially available mercury test paper sensitive only to mercuric ions. For some of the more promising chemical spot tests, this report includes step-by-step instructions for field application.

IC 8922. Measuring Noise From a Continuous Mining Machine, by Roy Bartholomae, John Kovac, and John Robertson. 1983. 17 pp. 14 figs. Noise generated by continuous mining machines in underground coal production is an important health hazard. Bureau of Mines Contract J0387229 covers investigation of this noise through laboratory tests of simulated cutting operations and through in-mine noise measurements. The results of these investigations indicate that coal cutting noise and conveyor noise are dominant sources of mining machine operational noise. Typical noise levels for both cutting and conveying operations are approximately 97 dBA (decibels A-weighted). For full operation of all machine systems, the overall sound pressure level is approximately 101 dBA. In-mine and laboratory test results show excellent agreement in both A-weighted overall levels as well as in A-weighted one-third-octave band spectra.

IC 8923. Aluminum From Domestic Clay Via a Chloride Process. The State-of-the-Art, by A. Landsberg. 1983. 15 pp. 3 figs. Kaolinitic clays are potentially a vast domestic resource for aluminum. Utilization of this resource could decrease or eliminate the nearly complete dependence of the United States on foreign raw materials for this important metal. Furthermore, processing of clay to aluminum through anhydrous chloride metallurgy could reduce the high electrical energy requirements of the conventional Hall-Heroult aluminum reduction process. Several anhydrous chloride processes have been proposed; however, unresolved technical problems have prevented their commercialization. In particular, an acceptable chemical means has not been found to extract aluminum from clay as a highly pure anhydrous aluminum chloride. This Bureau of Mines report identifies and discusses the important chemical problems involved in achieving an acceptably rapid self-heating, selective chlorination reaction and the subsequent separation of iron chloride byproduct from the anhydrous aluminum chloride.

IC 8924. Updated Process Flowsheets for Manganese Nodule Processing, by Benjamin W. Haynes, Stephen L. Law and Riki Maeda. 1983. 100 pp. 73 figs. The Bureau of Mines, in cooperation with the National Oceanic and Atmospheric Administration (NOAA), has updated a 1977 NOAA report prepared by Dames & Moore entitled, "Description of Manganese Nodule Processing Activities for Environmental Studies." This updated report contains detailed flowsheets and descriptions of the five potential first-generation nodule recovery schemes now considered most likely to be used by industry; they are high-temperature gas reduction and ammoniacal leach, cuprion ammoniacal leach, high-temperature and high-pressure H_2SO_4 leach, reduction and HCl leach, and smelting and H_2SO_4 leach. The first three processes are three-metal recovery schemes (Cu, Ni, and Co) with the option of Mn

recovery from the tailings. The remaining two processes are four-metal (Cu, Ni, Co, and Mn) recovery schemes. All except the HCl process are assumed to use a nodule feed rate of 3 million tons per year (dry basis). Final metal products are Co powder and cathode Cu and Ni. A minor amount of Ni is also recovered as powder, and some Cu and Zn are recovered as mixed sulfides. Manganese in the four-metal processes is recovered as either manganese metal or ferromanganese. GPO stock No. 024-004-03117-9. \$4.75.

IC 8925. Explosives and Blasting Procedures Manual, by Richard A. Dick, Larry R. Fletcher, and Dennis V. D'Andrea. 1983. 105 pp. 102 figs. This Bureau of Mines report covers the latest technology in explosives and blasting procedures. It includes information and procedures developed by Bureau research, explosives manufacturers, and the mining industry. It is intended for use as a guide in developing training programs and also to provide experienced blasters an update on the latest state of technology in the broad field of explosives and blasting. Types of explosives and blasting agents and their key explosive and physical properties are discussed. Explosives selection criteria are described. The features of the traditional initiation systems—electrical, detonating cord, and cap and fuse—are pointed out, and the newer nonelectric initiation systems are described. Blasthole loading of various explosive types is covered. Blast design, including geologic considerations, for both surface and underground blasting is detailed. Environmental effects of blasting such as flyrock and air and ground vibrations are discussed along with techniques of measuring and alleviating these undesirable side effects. Blasting safety procedures are detailed in the chronological order of the blasting process. The various Federal blasting regulations are enumerated along with their Code of Federal Regulations citations. An extensive glossary of blasting-related terms is included along with references to articles providing more detailed information on the aforementioned items. Emphasis in the report has been placed on practical considerations. GPO Stock No. 024-004-02113-6. \$5.50.

IC 8926. Minerals Availability Commodity Directory on Phosphate, by Dale R. Spangenberg, Edward F. Carey, and Paul M. Takosky. 1983. 678 pp. This Bureau of Mines Information Circular on phosphate is one of a series of minerals availability commodity directories. Nonconfidential information from the Minerals Availability Program data base covering 148 domestic and 103 foreign phosphate properties and deposits has been abstracted for use in this directory. Abstracts include applicable data on location, published reserves and resources, geology, mine and beneficiation systems, and operational information.

IC 8927. Helium Resources of the United States, 1981, by Floyd R. Hertweck, Jr., and Richard D. Miller. 1983. 17 pp. 7 figs. The helium resources of the United States were estimated by the Bureau of Mines to be 1,037 Bcf as of January 1, 1981. These resources are divided into four categories, in decreasing degree of assurance of their existence: (1) helium in storage and in measured natural gas reserves, which totals 211 Bcf, (2) helium in indicated natural gas resources, which is estimated at 207 Bcf, (3) helium in hypothetical natural gas resources, which is estimated to be 318 Bcf, and (4) helium in speculative natural gas resources which makes up the remaining 301 Bcf. These helium resources are further divided into depleting, non-

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depleting, and stored classifications. The depleting resources are those associated with natural gasfields that are, or will be, produced for the natural gas they contain. All of the helium in undiscovered (hypothetical and speculative) natural gas resources is included in this classification. These depleting resources are estimated to contain 897 Bcf of the total helium resource base. Nondepleting resources are those in shut-in, abandoned, or otherwise nonproducing natural gasfields. Helium resources contained in nondepleting natural gas resources are estimated to total 100 Bcf. There is 40 Bcf of helium in storage in the Federal Government-owned Cliffside Gas Field near Amarillo, Tex.

IC 8928. Chemical Vapor Deposition of Group IVB, VB, and VIB Elements With Nonmetals. A Literature Review, by H. O. McDonald and J. B. Stephenson. 1983. 29 pp. The Bureau of Mines reviewed the chemical vapor deposition (CVD) literature on the nonmetal binary and ternary compounds of the group IVB, VB, and VIB elements, with emphasis directed to the following nonmetals: B, C, N, O, and Si. This review examines each of these binary and selected ternary compounds of the group IVB, VB, and VIB elements as coatings and gives some of their preparative methods, uses, and properties. A total of 259 references were found for these compounds of the nine elements. This review was utilized in the Bureau's research to provide abrasion-, erosion-, and corrosion-resistant coatings in order to conserve critical metals and protect various metallic surfaces in metallurgical, mining, and energy conversion systems.

IC 8929. Economic Evaluation of Borehole and Conventional Mining Systems in Phosphate Deposits. by Joseph A. Hrabik and Douglas J. Godesky. 1983. 34 pp. 5 figs. The Bureau of Mines compared the feasibility of mining deep phosphate deposits by a borehole mining system with mining by proven conventional techniques. An economic comparison of the borehole mining system with conventional dragline and bucket wheel excavator mining systems was completed at various mining depths and production rates. Hypothetical phosphate deposits, with various overburden thicknesses and reserve tonnages, were defined. Geologic conditions necessary for the application of the borehole system were identified. Discounted cash flow analyses based on derived capital and operating costs were used to generate rates of return and product prices. Borehole mining was found to be more economical where overburden thickness was 150 ft or greater; however, at 50- and 100-ft thicknesses, conventional surface mining was more economical. Overburden thickness has a great effect on the economic feasibility of the conventional mining systems but less effect on the economics of borehole mining. Economies of scale are only realized in conventional mining, since larger equipment is employed to achieve greater production, whereas increased production from borehole mining is achieved using additional equipment units. A comparison of the environmental effects of borehole and conventional surface mining systems showed that borehole mining is environmentally more desirable.

IC 8930. Copper Availability—Market Economy Countries. A Minerals Availability Program Appraisal, by R. D. Rosenkranz, E. H. Boyle, Jr., and K. E. Porter. 1983. 30 pp. 16 figs. The Bureau of Mines has investigated the availability of copper from 272 deposits in market economy countries. The deposits studied have demonstrated resources totaling 413

million metric tons of contained copper and account for more than 90 pct of the reserve base for market economy countries. Using data gathered as part of its Minerals Availability Program, the Bureau performed geologic, engineering, and economic evaluations in order to determine the copper production potential of each deposit. At the 1981 copper market price of \$0.85/lb, the deposits studied could economically produce an estimated 88 million metric tons of copper (allowing for profit computed at a 15-pct rate of return), primarily from mines operating at the time of the study (1981). At this price, producing mines in market economy countries could economically produce only 2.1 million metric tons of refined copper per year. However, actual 1981 production was 6.2 million metric tons, indicating that many mines continued to operate even though they were unable to cover all production costs. For U.S. producing mines, the estimated average cost of production per pound (including profit at a 15-pct rate of return) was \$0.15 higher than the average cost in other market economy countries. GPO Stock No. 024-004-02128-4. \$2.

IC 8931. Economic Evaluation of a Method To Regenerate Waste Chromic Acid-Sulfuric Acid Etchants, by Deborah A. Spotts. 1983. 7 pp. 3 figs. Researchers at the Bureau of Mines have developed a technique for regenerating chromic acid-sulfuric acid etching solutions used in metal surface treatment operations. The technique utilizes a diaphragm cell equipped with a cation-selective membrane to oxidize Cr^{3+} to Cr^{6+} at the anode and to remove copper, the major metallic contaminant, at the cathode. Normally, spent etchant is discarded after approximately 3 days of use. Using the electrolytic cell, the etchant can be used for a year without replacement. From data obtained from industrial-scale cells, the installation of a regeneration cell with a 1,000-gal catholyte-holding tank has been estimated to save at least \$240 per day. The payback period for the investment is estimated to be about 10 mo or less. Because the magnitude of these cost savings will vary at different locations, several graphs are presented to aid in calculating payback for a specific site. Using these graphs and the capital costs presented in this study, the payback period can be determined for installing a regeneration cell with a 500- or a 1,000-gal catholyte-holding tank in an existing surface treatment plant.

IC 8932. Costs and Effects of Environmental Protection Controls Regulating U.S. Phosphate Rock Mining, by Ronald F. Balazik. 1983. 37 pp. 1 fig. This Bureau of Mines study identifies and examines the costs of Federal, State, and local environmental protection controls on domestic phosphate rock mining. The costs include the expenditures needed to comply with government regulations and the effects that these expenditures and regulations have on supply. The study analyzes costs of environmental impact assessments, air and water quality standards, reclamation laws, potential solid waste controls, and local government restrictions. In addition, an industry survey and the Bureau's Minerals Availability System (MAS) are used to evaluate land management policies that restrict access to phosphate resources. Conclusions drawn from these analyses confirm that (1) domestic phosphate mining has incurred substantial control costs and may be subject to significant new regulatory costs in the next several years, (2) certain environmental controls can discourage mining investment, (3) environmental policies governing land-use controls affect the disposition of sizable phosphate resources and

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are key determinants in the development of those resources on the Federal domain, and (4) environmental costs could diminish the competitiveness of domestic producers.

IC 8933. Manganese Nodule Resources of Three Areas in the Northeast Pacific Ocean: With Proposed Mining-Beneficiation Systems and Costs. A Minerals Availability System Appraisal, by C. Thomas Hillman. 1983. 60 pp. 15 figs. The practical concern of economic minability of large, high-grade manganese nodule deposits in the northeast Pacific Ocean is addressed in this Bureau of Mines report. Principal objectives are to (1) estimate tonnage and grade of deposits with significant potential and (2) describe and estimate profitability of operations designed to mine and process deposits with greatest apparent potential. Analysis of data from over 800 ship stations identified three areas for detailed study. Average metal contents of these areas range from 1.30 to 1.45 wt pct nickel, 1.00 to 1.24 wt pct copper, 0.21 to 0.26 wt pct cobalt, and 26.8 to 27.8 wt pct manganese. Estimated recoverable nodule resources are 67.0, 66.9, and 148.8 million dry metric tons (t). A system to mine, transport, and process nodules from the three sites is described and costed. Although hypothetical, the system utilizes hydraulic mining and Cuprion (Kennecott) processing, which have been successfully tested at pilot scale. Nickel, copper, and cobalt are the three primary products, but ferromanganese is a considered option. Estimated capital requirements are approximately \$1.5 to \$1.7 billion for three-metal production. If ferromanganese were recovered, an additional investment of about \$130 million would be required. Operating costs range from \$71 to \$83 per dry metric ton of nodules without manganese, and from \$103 to \$123 per dry metric ton with ferromanganese. Discounted cash flow analyses predict low returns, ranging from 2.7 to 5.2 pct with ferromanganese and from 4.1 to 6.0 pct without. GPO Stock No. 024-004-02120-9. \$5.50.

IC 8934. A Dynamic Gas-Mixing System, by C. R. Carpenter, J. E. Chilton, and G. H. Schnakenberg, Jr. 1983. 30 pp. 28 figs. A dynamic gas-mixing system assembled by the Bureau of Mines for the generation of precise gas mixtures from sources of concentrated or pure gases and diluent gases is described. A set of electronic mass flow controllers with maximum flows ranging from 10 to 5,000 ml/min, a so-called Pure Air Generator, and gases in cylinders are used to generate differing gas concentrations. The repeatability of the delivery rate of a flow controller, measured on different days, has a precision of 0.3 pct of the setting. This dynamic gas-mixing system reduces the cylinder inventory and the demurrage charges for special gas mixtures. Gas mixtures that cannot be shipped commercially, such as flammable mixtures of methane in air, can be conveniently prepared by this system. The maximum dilution ratio is 2.5×10^4 . Thus, gas mixtures can be made over a wide range of concentrations, from the percent region (by dilution of a pure single-component gas) to fractional parts per million (by dilution of a premixed standard, e.g., a 1,000-ppm mixture). This system is especially useful in determining the response of gas detection devices over the entire range of their measurement. Because the controllers are voltage controlled they lend themselves easily to automated control using computer-based systems.

IC 8935. Minerals Data Source Directory, January 1983. (An Update of IC 8881), compiled by the Minerals Data Working Group, Interagency Minerals

Information Coordinating Committee. 1983. 376 pp. The Minerals Data Source Directory is a compilation of descriptive information on the availability, content, and location of minerals data in the Federal Government. It is intended to assist Government personnel and the general public in locating and acquiring minerals information. Included in the Directory are descriptions of data bases, publications, information systems, and information offices containing data pertaining to all aspects of mineral production, consumption, trade, and related information. These mineral data sources include the Federal agencies such as the Department of the Interior's Bureau of Mines and Geological Survey whose major mission is the collection and dissemination of mineral information. Also included are agencies such as the Departments of Agriculture, Commerce, Labor, State, Transportation, and Treasury, the Central Intelligence Agency, the Environmental Protection Agency, the Federal Reserve System, the Interstate Commerce Commission, and the Securities and Exchange Commission, whose primary mission is the collection of data in nonmineral subject areas, but in which the mineral industry is a component. GPO Stock No. 024-004-02116-1. \$9.50.

IC 8936. Electron Microscopy Studies of Explosion and Fire Residues, by Daniel L. Ng, Kenneth L. Cashdollar, Martin Hertzberg, and Charles P. Lazara. 1983. 63 pp. 52 figs. This Bureau of Mines report describes the results of scanning electron microscopic (SEM) studies of the combustion residues of carbonaceous dust particles resulting from explosions and thermal ignitions in laboratory and full-scale mine tests. The dusts studied varied widely in rank and volatility: Pittsburgh seam bituminous coal (35% volatility), Pocahontas seam bituminous coal (16% volatility), anthracite (7% volatility), graphite, and diamond. The most systematic explosion studies were performed in an 8-L chamber with narrow size distributions of Pittsburgh coal dust with surface mean diameters of 2, 22, and 84 μm . Experiments were conducted mainly in air, with some data obtained in 50% O_2 . Observations of the bituminous coal explosion residues showed particles with rounded edges, particles with blowholes, and some cenospheres. The lower volatility dust residues showed fewer changes from the original, unburned dust. In addition to the experimental studies, results of SEM observations of residues from a mine explosion disaster are reported. Comparison of such residues with those from the laboratory and experimental mine explosions can help investigators determine the extent of dust participation in the disaster and in identifying the possible ignition sources.

IC 8937. Phosphate Rock Availability—Domestic. Minerals Availability Program Appraisal, by R. J. Fantel, D. E. Sullivan, and G. R. Peterson. 1983. 57 pp. 20 figs. To determine the availability of phosphate rock from domestic resources, the Bureau of Mines evaluated the potential production of phosphate rock from the demonstrated resources of 130 mines and deposits. The evaluation included an estimation of resources, engineering methods, and capital and operating costs, and an economic analysis to determine each operation's average total cost of production over the life of the mine, including a 15-pct discounted-cash-flow rate of return on all investments. Quantified but not evaluated in this report are substantial phosphate resources at the inferred and hypothetical resource levels. The 130 mines and deposits contain 6.4 billion tons of recoverable phosphate rock product, about 20 pct from produc-

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ing mines. At total production costs of under \$30 per ton in January 1981 dollars, about 1.3 billion tons of phosphate rock product is potentially available, over 90 pct from producing mines. This study suggests that production from low-cost, high-grade phosphate mines now in operation will decline during the next decade, and new higher cost, lower grade mines will have to be developed to satisfy demand into the next century. In addition to the demonstrated resources evaluated in this study, 7 billion tons of inferred-level and 24 billion tons of hypothetical-level phosphate rock are potentially recoverable, which, in part, includes material containing high amounts of magnesium. Much of this material could likely become available in the near future.

IC 8938. New Developments in Personal Lighting Systems for Miners, by William H. Lewis and Elio Ferreira. 1983. 10 pp. 11 figs. Energy Research Corp., under contract to the Bureau of Mines, has developed a new miners' caplamp battery. The new battery is based on nickel-cadmium technology and offers significant improvements in performance with reduced size and weight when compared to the conventional lead-acid battery presently in use. This report describes the design and fabrication of the nickel-cadmium battery, which utilizes a roll-bonded electrode structure. The final battery design has a 15-A·h capacity in a 2½-lb package, which is over 2 lb lighter than the present lead-acid caplamp battery.

IC 8939. Passive Encoder for Range Knobs, by William H. Schiffbauer. 1983. 8 pp. 8 figs. The Bureau of Mines has developed a passive encoder for range knobs, a device that automates the task of obtaining the range settings from devices or instruments to be input to microcomputers. It is easily constructed and installed and will not disrupt the device to which it is being attached. It consists of a custom knob and a small printed circuit board that has light-emitting diodes and magnetic reed switches attached. A ribbon cable connects it to a microcomputer. This encoder eliminates one source of human error in an automated process.

IC 8940. Evaluation of Alumina Extraction From Coal Waste: Composition and Availability, by Roy T. Sorensen and John L. Schaller. 1983. 19 pp. 2 figs. This Bureau of Mines report presents the results of a study to rank technologies for extraction of alumina from bottom ash and coal shale. The available literature on composition and availability of coal waste was reviewed, and papers pertinent to alumina extraction are referenced. Types of coal waste were categorized by method of waste generation, coal content (heating value), location, coal type (ash nomenclature), and alkaline earth content. The differences and similarities among the categories of coal waste are summarized as to factors that may affect aluminum extraction, especially factors concerning chemical composition, current production, storage problems, and accumulated tonnage. Data available on physical characteristics and mineralogy did not correlate well with the individual categories of coal waste, and discussion on these two aspects is limited to the differences between coal ash and coal shale.

IC 8941. Field Determinations of a Probabilistic Density Function for Slope Stability Analysis of Tailings Embankments, by P. C. McWilliams and D. R. Tesarik. 1983. 26 pp. 12 figs. Theoreticians in soil mechanics have been pursuing a probabilistic approach

to the factor of safety of an embankment or dam for the past 10 years. The motivation for this work is in contrast to the current practice of deterministically computing a factor of safety and treating it as an absolute with no regard to its inherent statistical variability. Basic to the probabilistic approach is the selection of an appropriate statistical model to represent the histogram or probability density function (PDF) of the factor of safety values. Rather than simply assuming which PDF is appropriate, the Bureau of Mines collected data at two waste disposal embankments for consideration. This report addresses three candidate models, using the techniques of nonlinear curve fitting, and identifies the "best" model. A propagation of error formula for estimating the variability of Fellenius' factor of safety is also discussed.

IC 8942. Analyses of Natural Gases, 1982, by Richard D. Miller and Floyd R. Hertweck, Jr. 1983. 100 pp. 1 fig. This Bureau of Mines publication contains analyses and related source data for 271 natural gas samples from 22 States collected during calendar year 1982. All samples were obtained and analyzed as part of Bureau of Mines investigations of the occurrences of helium in natural gases of countries with free market economies. This survey has been conducted since 1917. The analyses published herein were made by the mass spectrometer and chromatograph.

IC 8943. Interim Performance Specifications for Transducer Modules Used With the Bureau of Mines Intrinsically Safe Mine Monitoring System. Carbon Monoxide, Methane, and Air Velocity, by J. E. Chilton and A. F. Cohen. 1983. 20 pp. 1 fig. Interim performance specifications are presented for carbon monoxide, methane, and air velocity transducers used in the Bureau of Mines intrinsically safe mine monitoring system. These specifications give quantitative values or qualitative descriptions of the transducers, including environmental parameters and monitoring system measurement and maintenance requirements as recommended by the Bureau of Mines. Commercially available transducer modules and prototype modules are listed together with selected characteristics.

IC 8944. Computerized, Remote Monitoring Systems for Underground Coal Mines. Faults in Power Systems, by Jeffrey H. Welsh. 1983. 11 pp. 2 figs. The Bureau of Mines studied the use of computerized, continuous, remote monitoring systems for safety from power system faults in underground coal mines. In this report the need to improve protection against power system faults is documented, and types of faults are identified. The relationship between mine safety regulations and computerized, continuous, remote monitoring is analyzed.

IC 8945. Agglomeration-Heap Leaching Operations in the Precious Metals Industry, by G. E. McClelland, D. L. Pool, and J. A. Eisele. 1983. 16 pp. 12 figs. During the 1970's, the Bureau of Mines investigated a particle agglomeration technique for improving the flow of leaching solution through heaps of clayey or crushed, low-grade gold-silver ores, wastes, and tailings. This technology has been adopted on a broad scale by the precious-metals-processing industry. This report presents information on five commercial operations that have benefited from

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agglomeration technology and that represent a cross section of current heap leaching practice. The technology is cost effective because of decreased leach times and improved precious metal recoveries.

IC 8946. Selected Raw Material Requirements for Japan's Specialty Steel Industry, by E. Chin, John C. Wu, L. Nahai, Gordon L. Kinney, and Charles L. Kimbell. 1983. 34 pp. Although Japan is a major producer of crude steel, it is poor in industrial raw materials. This Bureau of Mines report describes Japan's raw material needs for chromium, cobalt, manganese, nickel, and tungsten to produce ferroalloys and alloy steels. Japanese imports of these ores or metals by quantity and source are given for 1972-81, inclusive, to indicate (1) the changes in the consumption and supply pattern, and (2) the degree of Japan's dependence on foreign sources. This report also describes measures implemented by Japan to reduce the risk of supply interruption, and discusses the possible implications of supply shortages. GPO Stock No. 024-004-02122-5. \$3.75.

IC 8947. Safety in the Use and Maintenance of Large Mobile Surface Mining Equipment. Proceedings: Bureau of Mines Technology Transfer Seminars, Tucson, AZ, August 16, 1983, Denver, CO, August 18, 1983, and St. Louis, MO, August 23, 1983, compiled by Staff, Bureau of Mines. 1983. 97 pp. 64 figs. These proceedings consist of papers presented at Bureau of Mines Technology Transfer Seminars in August 1983 for the purpose of disseminating recent advances in mining technology in the area of large mobile surface mining equipment safety and health. The following papers were either presented at the seminar or relate to the subject. The topics covered are ingress-egress safety, collision avoidance, novel truck design, operator alertness studies, rollover protective structures, operator restraint devices, maintenance safety, operator safety training, improved haul road berm design, stability indicators for front-end loaders, and retrofit noise control for bulldozers. The Bureau of Mines conducts several of these seminars each year in order to bring the latest results of Bureau research to the attention of the mining industry as quickly as possible.

IC 8948. Back Injuries. Proceedings: Bureau of Mines Technology Transfer Symposia, Pittsburgh, PA, August 9, 1983, and Reno, NV, August 15, 1983, compiled by James M. Peay. 1983. 110 pp. 43 figs. These proceedings consist of papers presented at two Bureau of Mines Technology Transfer symposia on reducing back injuries in the mining industry. The symposia were held in August 1983 and covered a wide range of topics related to a more fundamental understanding of factors that lead to back injuries and approaches for reducing the frequency and severity of such injuries.

IC 8949. New Techniques for Reducing Stopping Leakage, by Robert J. Timko and Edward D. Thimons. 1983. 15 pp. 14 figs. Because of leakage through and around permanent stoppings in underground mines, more air must be forced into a mine than would otherwise be required for ventilation. As power costs increase, costs resulting from air leakage add increasingly to the operating costs of mining. The Bureau of Mines evaluated four different stopping construction techniques based on the ideas that (1) airtightness could be enhanced by brushing rather than troweling on mortar sealant and that (2) modified mortars (mortars containing glass fibers and other additives for increased

strength and adhesion) would improve sealing performance. Air leakage tests comparing conventional to modified stoppings were done when the stoppings were built, after 6 months, after 1 yr, and following simple maintenance. It was found that stoppings can be built and maintained better if (1) the area where a stopping is to be built is properly prepared; (2) stoppings are periodically examined for leaks; and (3) stoppings found to be leaking, especially at the perimeters, are resealed.

IC 8950. Fresnel Lens Blind Area Viewers for Improved Mine Equipment Safety and Productivity, by Guy A. Johnson. 1983. 15 pp. 20 figs. Combining contract and in-house research, the Bureau of Mines has developed and in-mine tested a novel device to improve the field-of-view of operators of off-highway mining equipment. This device utilizes a downward-looking, flat fresnel lens. The lens, plus louvers to reduce glare, is housed in a protective steel structure. The complete unit is called a blind area viewer. The viewer, when mounted on the right-front corner of the deck of most large haulage trucks, will increase a driver's direct field-of-view from about 35 pct (of where he/she has to drive) to about 80 pct. The improved visibility allows the driver to see possible collision hazards and roadway obstacles better, thus improving mine safety and increasing productivity. Economic analysis shows that the blind area viewers, which are now commercially available, pay for themselves in about a month on a 170-ton-capacity truck. The viewers are also applicable to other large mining equipment, such as front-end loaders, draglines, and downhole drills, or any place where seeing around a corner would be advantageous, such as along conveyor flights in processing plants during startups.

IC 8951. Bureau of Mines Coal Cutting Technology Facilities at the Twin Cities Research Center, by Wallace W. Roepke, Carl F. Wingquist, Richard C. Olson, and Bruce D. Hanson. 1983. 26 pp. 26 figs. Research on coal cutting at the Bureau of Mines Twin Cities Research Center (TCRC) has evolved from a purely mechanical approach, specifically to reduce dust or frictional methane ignitions, into an understanding of the complexity of the cutting system relationships. Achieving an understanding of these relationships requires a wide variety of testing techniques and equipment. Laboratory facilities and the associated equipment exist for shallow to deep cutting in both coal and coal-inclusive rock with any desired bit type. Research efforts with this equipment are providing insight for significant advances to help solve the problems of pneumoconiosis and frictional ignition. This effort will ultimately affect both respirable dust and methane ignitions at the face through better bit design and will increase the salable percent of run-of-mine coal processed. It will also affect the design of rotary-drum cutting continuous mining machines and long-wall machines. This report describes the main features of the coal cutting research facilities at TCRC.

IC 8952. Rates of Chlorination of Aluminous Resources, by N. A. Gokcen. 1983. 14 pp. 8 figs. This Bureau of Mines report reviews and summarizes recent studies of the rates of chlorination of aluminous resources with CO and Cl₂ mixtures with and without COCl₂. No reaction mechanism could be obtained from the existing results; however, diffusional barriers in the gas and solid layers probably

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control the chlorination rate in thermogravimetric experiments. Fluidized beds of particles smaller than 0.1 mm appeared to show very little solid layer diffusional barrier. For optimum chlorination the particle size should probably be less than 8 mm, the calcination temperature approximately 700° C, and the chlorination temperature from 650° to 750° C. Relatively rapid chlorination with COCl_2 in thermogravimetric experiments was attributed partly to the simultaneous supply of reductant and chlorinator by one gas to the sample reaction site. Comparable results for chlorination of fluidized beds with COCl_2 are not available. Equimolar mixtures of CO and Cl_2 produced the optimum rate of reaction. Addition to the calcine of 10 to 20 wt-pct NaCl accelerated the rate of chlorination, and addition of SiCl_4 to the gas mixture decreased the rate of chlorination of SiO_2 drastically, but at the expense of chlorination of significant fractions of Al_2O_3 . Further research in various areas is suggested.

IC 8953. Methods for Characterizing Manganese Nodules and Processing Wastes, by Benjamin W. Haynes, David C. Barron, Gary W. Kramer, and Stephen L. Law. 1983. 10 pp. Analytical procedures are described for the quantitative determination of 16 elements (As, Ba, Be, Cd, Co, Cr, Cu, Fe, Mn, Mo, Ni, Pb, Sb, Se, Ti, and Zn) and 7 ionic species (NH_4^+ , CO_3^{2-} , Cl^- , F^- , NO_3^- , PO_4^{3-} , and SO_4^{2-}), identification of major and minor mineral components, and measurement of physical properties associated with manganese nodules and nodule processing reject waste materials. Compound identification methods discussed include X-ray diffraction, infrared spectroscopy, scanning and transmission electron microscopy, selective area electron diffraction, and optical and reflected light microscopy. Methods for elemental analysis include atomic absorption spectrophotometry, inductively coupled plasma emission spectroscopy, neutron activation analysis, fluorescent X-ray spectrography, and ion chromatography. Thermal gravimetric analysis, ultraviolet-visible spectrophotometry, ion specific electrodes, and standard wet chemical procedures are briefly discussed. Physical properties determined in manganese nodule materials include grain size distribution, specific gravity, triaxial shear, permeability, maximum density, Atterberg limits, and slurry density. The results of a round-robin analysis of an ammonia process waste material and manganese nodule standards demonstrate the applicability of the discussed methods. Tests discussed for the evaluation of the waste materials for disposal options include the Environmental Protection Agency (EPA) EP toxicity test, the ASTM shake extraction test, and the U.S. Army Corps of Engineers EPA seawater elutriant test.

IC 8954. Automatic Fire Protection for Mobile Underground Mining Equipment, by Guy A. Johnson. 1983. 12 pp. 17 figs. To improve productivity and cut costs, modern underground mining operations have become more mechanized. This mechanization has increased the usage of fuels, hydraulics, and electrical equipment associated with diesel-powered vehicles, thereby also increasing the hazards of underground mine fires. The Bureau of Mines evaluated the fire hazard problem and assembled prototype components for a system that would automatically sense and extinguish fires on mobile underground equipment. The prototype system and alternative designs were in-mine tested and proved effective. This report summarizes this tech-

nology, which can cost effectively help solve the problem of fire hazards on underground vehicles.

IC 8956. Health and Safety In-House and Contract Research in Fiscal Year 1984, by Staff, Division of Health and Safety Technology. 1983. 20 pp. This publication summarizes the research (in-house and contract projects) programed by the Bureau of Mines for fiscal year 1984 (October 1, 1983-September 30, 1984) under its Health and Safety Technology Program. The objective of these projects is to provide an ordered and sequenced advance toward the Bureau's overall goal of providing the systems technology required to create a more healthful and safer working environment for the Nation's mining and minerals processing workers.

IC 8957. Dust Sources and Controls on the Six U.S. Longwall Faces Having the Most Difficulty Complying With Dust Standards, by Robert A. Jankowski and John A. Organiscak. 1983. 19 pp. 11 figs. The Bureau of Mines has recently identified five major factors that contribute to high respirable dust levels on the six U.S. longwall faces having the most difficulty complying with Federal dust standards: (1) a poorly structured cutting sequence, (2) a poorly designed external water spray system, (3) marginal waterflow to the cutting drums, (4) minimal controls at the stage loader and crusher, and (5) the lack of effective controls for dust generated during support advance. The results of this survey illustrate the need to address all the major sources of longwall dust generation and the need for mine operators to implement a variety of control procedures to assure compliance. The Bureau of Mines will continue to assist mine operators in implementing improved dust controls and will work to identify and evaluate controls for dust generated during support advance.

IC 8958. Cost Estimate of the Bayer Process for Producing Alumina—Based on 1982 Equipment Prices, by Deborah A. Kramer and Frank A. Peters. 1983. 20 pp. 6 figs. This Bureau of Mines report presents a cost estimate of the Bayer process, which is used for virtually all cell-grade alumina production. The report will serve as a reference point to determine the economic merits of processes that have evolved from Bureau of Mines investigations on technology for producing alumina from domestic nonbauxitic raw materials. The Bayer process involves dissolving the alumina present in bauxite in a caustic solution at high temperature and pressure. After the undissolved impurities are removed, the solution is seeded to produce an alumina trihydrate precipitate. This precipitate is filtered, washed, and calcined to produce the cell-grade alumina product. This cost estimate is for a plant producing 1 million tons of alumina per year. The estimated operating cost is approximately \$250 per ton of alumina.

IC 8959. Economic and Technical Evaluation of the Sulfurous Acid-Caustic Purification Process for Producing Alumina From Kaolinitic Clay, by Deborah A. Kramer. 1983. 26 pp. 9 figs. An economic and technical evaluation of a proposed process to recover alumina by leaching calcined kaolinitic clay with sulfurous acid is presented in this Bureau of Mines report. After the insoluble portion of the clay has been removed by leaching, monobasic aluminum sulfite is precipitated from the pregnant leach solution by partial hydrothermal decomposition. Further heating completes the decomposition to an impure alumina hydrate. This intermediate is purified in a modified Bayer process, which includes dissolving

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the alumina hydrate in a caustic solution at high temperature and pressure, then decreasing the temperature and pressure to precipitate alumina trihydrate. Calcining the trihydrate produces the alumina product. A cost estimate was prepared for a plant producing 1,000 tons of alumina per day, 350 d/yr. The estimated operating cost is approximately \$475 per ton of alumina. This is substantially higher than a comparable estimated operating cost for the Bayer process of \$250 per ton of alumina. The proposed process does not appear economically attractive, even as a method to modify a current Bayer processing plant to use a kaolinitic clay feed. High capital costs and high energy requirements make the process prohibitively expensive.

IC 8960. Microseismic Instrumentation Developments. A

Tape-Triggering System and Energy Analyzer, by Bernard J. Steblay. 1983. 12 pp. 8 figs. Two instruments have been constructed that extend microseismic data collection and processing capability for Bureau of Mines research in rock burst, coal bounce and outburst, and roof fall monitoring. The first instrument is a 13-channel tape-triggering system. This system allows better utilization of instrumentation tape recorders by collecting data digitally, turning the tape on only when valid data are present, and increasing the dynamic range of the recorder by using digital data. A digital-to-analog converter is used to provide analog output of the recorded digital data. The instrument records a much larger time slice of transient events than do current commercial devices. The second instrument is a microseismic energy measurement device. This device uses recent developments in integrated circuits to overcome the dynamic range and accuracy limitations of previous instruments. The analog signal is converted to a digital one, and then high-speed multiplication techniques are used to square the amplitude value in real time and integrate it.

IC 8961. In Situ Copper Leaching in the United States:

Case Histories of Operations, by Jon K. Ahlness and Michael G. Pojar. 1983. 37 pp. 16 figs. The copper industry has had a long and interesting history associated with leaching, involving vat, dump, heap, and in situ methods. The Bureau of Mines has also had an interest in copper leaching and has researched the techniques of solution recovery, particularly concentrating on in situ methods.

In situ mining is a relatively low cost method and has been proven commercially successful by mine operations. It has been most commonly used for final recovery in old workings at the conclusion of conventional mining operations. This report brings together information about 10 commercial in situ operations as well as 14 experimental projects. These 24 sites comprise most of the in situ copper mining activities that have taken place in the United States. Background information, geology, ore preparation, solution application, and recovery and processing are provided for each operation. Production data and tables summarizing the engineering statistics for each operation and an extensive in situ mining bibliography are included. GPO Stock No. 024-004-02127-6. \$2.

IC 8962. Lead and Zinc Availability—Domestic. A Minerals

Availability Program Appraisal, by Catherine C. Kilgore, Sylvia J. Arbelbide, and Audrey A. Soja. 1983. 30 pp. 22 figs. The Bureau of Mines investigated the availability of lead and zinc from 104 domestic mines and deposits. Fourteen primary lead and fifty-three primary zinc operations with in situ demonstrated resources containing 27.3 million metric tons (t) of lead and 53 million t of zinc were subsequently evaluated. Potentially 17.5 million t of lead and 2.4 million t of byproduct zinc could be recovered from 14 primary lead operations. Economic evaluations performed in constant January 1982 dollars determined a long-run total cost per pound of recoverable commodity. Including a 15-pct discounted-cash-flow rate of return (DCFRR), 59 pct of primary lead was potentially available at or below \$0.32 per pound of lead. Potentially 40 million t of zinc and 5.6 million t of byproduct lead could be recovered from 53 primary zinc operations. Ninety percent of the recoverable zinc is potentially available from currently nonproducing mines and deposits, and a weighted average of their long-run total costs was determined at \$0.98 per pound of zinc. At a break-even (0-pct) DCFRR, these nonproducing operations had a weighted average long-run total cost of \$0.58 per pound of zinc. Sensitivity analyses illustrated that operations that recover byproducts were most sensitive to fluctuating metal prices, producing operations were more sensitive to increased smelter treatment charges, and nonproducing operations were impacted most by the DCFRR. GPO Stock No. 024-004-02126-8. \$2.

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OFR 1(1)-83. Mine Rescue Team's Protective Ensemble.

Volume 1, by Victor Himel and Ernest V. Hansberry. May 1982. 30 pp. 24 figs. This report documents a systematic approach toward implementing an improved ensemble for the mine rescue team system that will protect against the hazards of mine rescue and recovery and will also afford improved performance through increased comfort and maneuverability, lighter burdens, and improved human engineering designs. Volume 1 is a detailed discussion of the approach to, and results of, three tasks. In the first task, the mine rescue team's protective needs were defined along with the test methods required to evaluate whether a particular piece of gear met these needs. The second task assessed existing gear against performance criteria and standards developed in the first task. The third task consisted of the conceptual design and construction phases of the mine rescue team's protective ensemble. Special consideration was given to advanced concepts, materials, and equipment. Research done under contract H0318048 by Grumman Aerospace Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-162826; paper copy price code A03.

OFR 1(2)-83. Mine Rescue Team's Protective Ensemble.

Volume 2, by Victor Himel and Ernest V. Hansberry. May 1982. 65 pp. 2 figs. This

report documents a systematic approach toward implementing an improved ensemble for the mine rescue team system that will protect against the hazards of mine rescue and recovery and will also afford improved performance through increased comfort and maneuverability, lighter burdens, and improved human engineering designs. Volume 2 presents the performance goals needed for the development of a mine rescue team's protective ensemble. Consisting of five integrated systems, the protective ensemble provides body protection, breathing gas, illumination, and communications capability. In defining the performance requirements and the associated test methods for their evaluation, the standards provide the foundation for the development of each of the systems comprising the protective ensemble. Research done under contract H0318048 by Grumman Aerospace Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-162818; paper copy price code A04.

OFR 2-83. Continuous Working Level Detector System,

by T. R. Strombotne and A. L. Beggs. May 1982. 27 pp. 8 figs. Studies show that the exposure of radon daughter products to miners in underground mines causes a fivefold increase in the incidence of lung cancer. To aid the uranium mining industry in complying with the standards enforced to limit exposure to these daughter products, the Bureau of Mines and the Mine Safety and Health Administration have been conducting studies on personal dosimeters to determine the most accurate measurement of working level exposure. This report documents a contract undertaken to develop a commercially available source of a continuous working level detector developed by the Bureau of Mines. The report contains a system and a circuit description of the continuous working level detector. Research done under contract H0212005 by TSA Systems, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-165187; paper copy price code A03.

OFR 3-83. Off-Highway Haulage Truck Overload Detection,

by J. A. Bartol. January 1982. 85 pp. 28 figs. A survey was made of accident data and operating practices related to overloading and uneven load distribution on haulage trucks in non-coal open pit mines. Safety and economic aspects were analyzed. A bibliography of the literature was

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prepared. Review was made of available or projected systems for weighing or load indicating that might be applied to haulage trucks. A model specification system was prepared for an overload detection system. Several promising systems for overload detection were identified. One was installed and tested briefly in a 170-ton rear dump truck in a copper surface mine. Research done under contract J0188070 by Applied Engineering Resources, Inc. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; National Library of Natural Resources, U.S. Department of the Interior, Washington, DC; and Office of the Assistant Director—Mining Research, U.S. Bureau of Mines, Washington, D.C. Order ONLY from NTIS: PB 83-163881; paper copy price code A05.

OFR 4-83. The Quenching Behavior of Coal Dust-Air Mixtures, by Frank T. Greene and J. Eugene O'Donnell. August 1981. 88 pp. 36 figs. The quenching behavior of coal dust-air flames was investigated. The literature relevant to coal dust-air flames was reviewed, including information on the agglomeration, sedimentation, and dispersal of dust clouds. The simple equations relating the various concentrations involved in dust flame propagation are given, and their implications are elaborated. It is shown that the concentrations seen by a moving flame in a sedimenting dust cloud can differ significantly from the concentration commonly measured in such experiments. The known dust cloud phenomena that appeared significant in flame propagation studies were experimentally evaluated, and quenching diameters, flame speeds, and lean propagation limits for several tube diameters were measured. For Pittsburgh seam coal, the minimum quenching diameter (MQD) for dust between 10 and 20 μm was found to be between 0.7 and 0.8 cm, and the lean propagation for 3.2-cm tubes was found to be approximately 200 mg/L. Similar MQD data were also obtained for Pocahontas and Sewell coals, Beulah lignite, and a 50-gal/ton oil shale. The effects of temperature, coal particle size, and propagation tube material were also investigated. Research done under contract J0166076 by the Midwest Research Institute. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-164665; paper copy price code A05.

OFR 5-83. Study of Mine Haulage Roadway Surface Safety Hazards, by E. Ohlsson, W. Watson, P. Cosby, and M. B. Elliott. Apr. 15, 1981. 161 pp. 9 figs. This study is divided into two sections. The first contains a summary of previous research projects on surface mine haulage systems and a bibliography of current information on design and maintenance. The second section discusses the relationship between design maintenance and associated hazards, presents a conceptual model that illustrates the interaction of the haulage system's components, and ranks common hazards according to the potential impact on mine safety. The ranking system was developed using the conceptual haulage system

model and is based on interviews and questionnaires involving mine personnel throughout the United States. Research done under contract J0100028 by Arthur D. Little, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-168088; paper copy price code A08.

OFR 6-83. Surface Oil Mining. A Technical and Environmental Assessment, by Michael Richings, Larry Lansing, and Leigh Readdy. October 1981. 266 pp. 41 figs. This report describes the work performed and the results obtained for a study to determine the environmental problems that would be encountered in the surface mining of the P.R. Spring tar sand deposit in Utah and the Kern River heavy oil sand deposit in California. The report includes a discussion of the criteria for selecting the two deposits; the existing site conditions for each deposit including geologic, hydrologic, and environmental; development plans for the mining and processing of the tar and heavy oil sands along with an economic evaluation of the deposits; and the environmental impacts resulting from the development of the two deposits and the mitigating procedures recommended to minimize these impacts. Research done under contract J0295027 by Golder Associates, Inc. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Office of Assistant Director—Minerals Research, Bureau of Mines, Washington, DC; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-168567; paper copy price code A12.

OFR 7-83. Face Ventilation Monitoring and Data Acquisition System, by George Quackenbos and Gary Tiani. April 1982. 78 pp. 22 figs. The objective of this program is the design, fabrication, and testing of an environmental system for operation in underground mines to assess the effect of various mining systems on the contaminant levels near the mine face and within return airways. To determine the effect on airborne contamination in mines resulting from the development of new mining techniques, equipment, and control systems, a comprehensive monitoring system was developed to assess such contamination levels at critical and strategic locations and to relate this information with ventilation parameters. The three variables to be sensed on a continuous basis are airborne dust concentration, methane concentration, and ventilation air velocity. Each monitoring station consists of a self-contained unit containing a power source and sensors to monitor the above-mentioned parameters. Ruggedness, reliability, ease of operation, and intrinsic safety are important design objectives. Data gathered by each monitoring station are fed to a central data acquisition system by a portable transfer unit. Research done under contract J0100032 by GCA Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Min-

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ing Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-170522; paper copy price code A05.

OFR 8-83. Selective Flocculation of Collophane, by Maurice C. Fuerstenau. May 1981. 67 pp. 40 figs. The adsorption of selected modifying agents (namely, starch, sodium, silicate, fluosilicic and oleic acids on collophane, calcite, and dolomite) was studied as a function of concentration and pH. Fluosilicate, silicate, and oleate anions chemisorb on collophane and dolomite, while high-molecular-weight starches hydrogen bond to these surfaces. Electrostatic adsorption of starch on calcite was also noted to occur. Selective flocculation of collophane from quartz and the carbonate minerals from three natural ores was achieved utilizing sodium silicate, sodium hexametaphosphate, and potato starch at pH 10.5. Additionally, small additions of polyelectrolyte were made to increase the settling velocity of the collophane floccules. With ores from Idaho and Florida, concentrates containing 32% to 33% P₂O₅ were satisfactorily recovered. However, several processing steps are required that result in large reagent consumption. Techniques are suggested to reduce the number of stages of concentrate cleaning. Research done under grant G0264028 by South Dakota School of Mines and Technology. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-168609; paper copy price code A04.

OFR 9-83. An Environmental Evaluation of Dust Suppressants: Calcium Chloride and Ligninsulfonates, by Rexford D. Singer, Jeffrey B. Stevens, Janine R. Gleason, David A. Baker, Thomas M. Baker, and Alan V. McEmber. June 1982. 35 pp. The purpose of this study was to evaluate the current literature on the use of calcium chloride and ligninsulfonates as dust suppressants with respect to potential adverse effects on health or the environment. Calcium chloride poses little internal hazard to humans and animals, but toxicity to vegetation in and around the area of application should be expected. The effects, however, should be considerably less than those observed from using calcium chloride as a road deicer. Except for trout, ligninsulfonates seem to pose little direct systemic toxicity problems in aquatic organisms, animals, and humans or any problems with local vegetation. Because of a greater volume of information on its use and effects, calcium chloride is recommended over ligninsulfonates. Research done under contract H0212027 by the School of Public Health, University of Minnesota. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-171967; paper copy price code A03.

OFR 10-83. A Study To Determine the Comparability of Pupillographic and Electrooculographic Measures in Determining Fatigue Effects in Truck Drivers, by John A. Stern and Larry C. Walrath. Jan. 4, 1982. 65 pp. 4 figs. Subjects were required to perform four vigilance tasks each lasting 32 minutes. The tasks involved temporal discrimination with a simple motor response required for the shorter duration signal. The ratio of short to long duration signal was 1:2. The short duration signal persisted for 200 ms; the long duration signal, for 400 ms. Two modes of stimulus presentation were used—auditory and visual—as well as two schedules of presentation—fixed interstimulus interval (2 s) and variable interstimulus interval ($\bar{X} - 2$ s). Electrooculographic and behavioral data were obtained. The results are summarized. Evaluation of the eyeblink alertness detector identified a number of problems with the device, which are summarized in the report. Research done under contract J0205064 by Washington University. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 11-83. Portable Trailing Cables, Splices, and Couplers Design and Installation Considerations, by L. A. Morley, J. N. Tomlinson, G. Moore, and D. E. Kline. Feb. 1, 1982. 96 pp. 61 figs. The principal concerns of this investigation were splice installations and considerations for the possible use of conductive-rubber shielding in low-voltage trailing cables and coupler installations in high-voltage cables. Flammability measurements on cable components and general testing facilities for mine electrical equipment were secondary tasks. Theoretical and empirical data indicate that conductive rubber with high resistivity values is an unsatisfactory shield design for current-sensing fault detection. It was found that the elimination of partial discharge in coupler installations requires meticulous care. A summary and recommendations for future work are included in the report. Research done under contract J0199106 by the Pennsylvania State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-170852; paper copy price code A05.

OFR 12-83. Assessment of Ground and Surface Water Effects Around Coal and Mineral Storage Areas, by Donald H. Koch, John R. Stetson, and Benjamin R. Genes. July 1982. 308 pp. 89 figs. Ten coal and mineral stockpile sites (5 coal and 5 mineral—phosphate, lead, copper, iron, and uranium) across the country were visited to determine the impact of the stockpiles on water quality. A series of leaching

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experiments was conducted in which drainage from the 10 coals and minerals was controlled and monitored to survey the extent to which storage piles release toxic ions to ground and surface waters. Pollution abatement techniques were reviewed in three generic treatment examples applied to lead-zinc ore, eastern coal, and uranium ore stockpile leachate. The study resulted in the following major conclusions: (1) Water quality impacts are site specific, (2) there is a high correlation between the sulfide content of a material and its solution potential, and (3) the selection of the best treatment alternative for a specific coal or mineral storage area must be based on site-specific criteria, pilot studies on representative leachate samples, and sound engineering design. Research done under contract J0199076 by Hittman Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-168575; paper copy price code A14.

OFR 13-83. Beneficial Use of Sulfur in Highway Pavements.

Characterization and Analysis of Plasticized Sulfur Concrete, by D. Saylak, D. N. Little, and S. W. Bigley. July 1982. 71 pp. 22 figs. This program was directed toward (1) establishing a familiarity with basic mix and sample preparation techniques, (2) material characterization, and (3) structural analysis of sulfur concrete mixtures using binders plasticized at 5, 10, 20, 30, and 40 percent. Suitable concrete specimens were prepared using the five binders. For mix design operations, the Marshall or Hveem procedures for asphaltic mixtures were found to be acceptable. For tests requiring larger size specimens such as unconfined compression and repeated-load creep, the California DOT Test Method 304 is preferred. Sulfur concrete mixtures were subjected to a characterization testing program designed to provide input to a linear viscoelastic pavement design system. A comparison of pavement performance characteristics such as rutting, roughness, cracking, and serviceability of sulfur concrete materials and asphaltic concretes indicated the former could be expected to behave as well as, or superior to, conventional pavement systems. The potential of an in situ characterization device called the Duomorph was investigated for monitoring property changes in the five modified-sulfur binders. An apparatus and testing procedure is described for measuring moduli of these binders over a range of test temperatures and loading rates. Research done under contract J0100100 by the Texas Transportation Institute. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-170670; paper copy price code A04.

OFR 14-83. Laboratory Experiments To Determine the Roof Behavior of Auger Mining With Aerostatic Support, by Madan M. Singh and Mark S. Ma. June

1982. 51 pp. 25 figs. The Bureau of Mines recently devised a method of mining that involves auger mining underground using aerostatic supports; that is, pressurized bladders inserted in the auger holes. Apart from other advantages that the method has to offer for underground productivity and safety, it permits controlled subsidence at the surface. Thus, large differential movements of the surface, which induce damage in structures, are prevented. This report describes model experiments in the laboratory that were conducted to obtain preliminary data for the design of field investigations. The results demonstrated the feasibility of the method and indicated that support pressures of 10 to 18 psi would be adequate for depths up to 1,000 ft and 70 pct recovery. The abutment loads do not exceed those generally encountered in longwall mining. Research done under contract J0295060 by Engineers International, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 15-83. Design of a Load Haul Dump Tree Transplant Attachment, by J. P. Workman, K. E.

Carlson, J. L. Smith, and K. A. Crofts. December 1980. 79 pp. 32 figs. Extensive transplanting of mature plants offers many advantages in mined land reclamation. Transplanted vegetation provides growing plants immediately to the barren reclaimed area. The front-end loader has been used on a limited basis for transplanting in the Western United States. However, these buckets are not suitable for transplanting because of their size and shape. Thus, a transplanting attachment, with straight back to prevent bending and damage to taller plants, was fabricated to facilitate moving the maximum surface area of soil and plants consistent with the capacity of the loader. One hundred and forty clumps of vegetation were transplanted using the transplant attachment. The survival, wildlife use, and invasion of surrounding area were inventoried. These data are included in the report. In addition, a preliminary functional evaluation was made of a transport machine. The machine was self-powered and had the capability to load, transport, and unload pads of vegetation. Research done under contract H0292001 by the Colorado State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-170621; paper copy price code A05.

OFR 16-83. Safe Organic Insulations and Fluids for Permissible Enclosures, by K. L. Paciorek, R. H. Kratzer, F. F. C. Lee, and J. H. Nakahara. June 1980. 168 pp. 66 figs. Explosion-proof electrical enclosures contain a variety of organic insulating materials of differing nature and chemical compo-

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sition. When subjected to thermal and/or electric stress, organic insulators may be potentially hazardous owing to moist tracking and thermal oxidative degradation. Organic materials utilized as cable jacketing, cable insulation, standoffs, insulating boards, and potting compositions were identified and a literature survey performed to obtain the required thermal oxidative and moist tracking data. Thirty representative compositions were procured and subjected to thermal and moist tracking evaluations. Tracking was found to invariably result in ignition or glow of the test specimen. Influence of parameters such as electrolyte strength and composition, temperature, conductor spacing, and electrode material were investigated. Volatiles produced by selected insulators on thermal oxidative and electrical stress were identified, quantitated, and their potential impairment action upon a current interrupter assessed. Research done under contract J0377075 by Ultrasystems, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-170712; paper copy price code A08.

OFR 17-83. A Ventilation Study With Pressure Cycling in a Kerr-McGee Mine at Ambrosia Lake, New Mexico, by J. E. Cleveland, J. D. Shreve, and Frank Moreno. July 1982. 62 pp. 13 figs The major health concern for uranium miners is the release of radon gas and the resultant ingrowth of the short-lived daughters in the mine atmosphere. Present methods of control are the utilization of mine ventilation systems for dilution and control of ingrowth time to maintain working levels below those set by regulations. This study examines pressure cycling effects on the radon emanation. The mechanical ventilation systems were altered to allow pressure changes throughout the mine to increase radon influx during the off shifts and thus deplete the sources of radon gas. Continuous radon working level and environmental monitors, developed by the Bureau of Mines, were employed to monitor radiation and physical parameters in the mine workings. The mine ventilation system was then varied to induce radon flows during off shifts, thus depleting the radon sources during normal production shifts. Electrostatic precipitators were also tested to determine radon daughter collection efficiencies. Both radon and radon daughter concentrations were monitored and evaluated. Major problems were found in the simple mechanical operation of cleaning these units. Research done under contract J0265058 by Kerr-McGee Nuclear Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 18-83. The International Stainless Steel Market: An Analysis of Supply, Demand, Prices and Trade Flows, by Per Baverstam, Thomas B. King, and Joel P. Clark. January 1982. 310 pp. 41 figs. A

mathematical model was developed to simulate the international market for stainless steel in the market economy countries. The model was constructed by analyzing stainless steel markets in four regions: the United States, Japan, Sweden, and the European Community. Regional interrelationships between stainless steel supply, demand, prices, and trade are taken into account. Analysis is based on historical data collected for each market covering the 1970-79 period. The data are used to illustrate changes in production technology, capacity, and costs over time and to show consumption of raw materials, energy, and stainless steel products. Demand for stainless steel is calculated for each region annually through 1990. Using forecasts from several macro-economic services available through 1981, simulation of the international market through 1990 indicates regional annual growth rates of stainless steel demand ranging from 5 percent in the United States to 7.9 percent in Japan, and growth rates of exports ranging from 5.3 percent annually for Sweden to 10.7 percent for Japan. Research done under contract J0199152 by the Massachusetts Institute of Technology. Available for reference at the National Library of Natural Resources, U.S. Department of the Interior, and Office of Assistant Director—Minerals Information, U.S. Bureau of Mines, Washington, DC. Order ONLY from NTIS: PB 83-170902; paper copy price code A14.

OFR 19-83. Contamination of Ground and Surface Waters by Uranium Mining and Milling. Volume II. Field Sampling and Empirical Modeling, by Gergely Markos and Kathryn J. Bush. December 1981. 127 pp. 17 figs. Uranium mill tailings represent a potential threat to the human habitat by containing large amounts of radioactive and chemically toxic substances in high concentrations. The main objective of this investigation was to evaluate the actual movement and model the potential movement of contaminants by seepage of water from the tailings into the subtailings soil. This report presents various models of the movement of contaminants using both theoretical approaches and empirical evaluation of data available from other investigations. The data consist of field measurements and laboratory determinations of major and trace cations, the dominant anions, pH, Eh, and specific conductance of solids and waters from the tailings and surroundings. Evaluation and interpretation of data were accomplished by using Eh-pH diagrams, various statistical methods, and the WATEQFC computer program. Data analysis shows that the critical area of investigating movements is the interfaces between tailings and the external environment. The chemical differences at interfaces seem to result in a sink system for contaminants. The tailings-soil-water system shows extreme complexities because of chemical and physical heterogeneity of the system preventing the use of a single comprehensive model to represent real conditions. The validity of the simplifying assumption used has been shown and increasing complexity has been built into the models. Analogs of these models can be used for evaluation of similar systems. Research done under contract J0295033 by the University of Colorado, Denver, and GEC Research, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and National Library of

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Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 88-170688; paper copy price code A07.

OFR 20-83. Resilient Screen Test Program, by William R. Wessels. January 1982. 55 pp. 24 figs. This report describes a field survey and laboratory investigation into the causes of resiliently clad screen decks applied to coal preparation plants. Blinding of screen deck perforations and delaminations of the resilient cladding are studied and mechanisms responsible for these failure modes are hypothesized. A laboratory test program to simulate the mechanisms was begun and abandoned when it became apparent that meaningful test results would require a substantially redirected effort. No meaningful test data were obtained from the laboratory simulation. Research done under contract J0100042 by Wyle Laboratories. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-171983; paper copy price code A04.

OFR 21-83. Explosion Proof High and Medium Voltage Connector, by M. S. Cetiner. March 1982. 70 pp. 32 figs. This report describes the prototype development of a medium to high voltage coupler, suitable for underground coal mining operations. The coupler has such unique features as automatic dust covers and continuous phase pin shielding. The coupler is rated at 7,500 V and 250 A continuous operation. Research done under contract H0188155 by Foster-Miller Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 22-83. Rheology of Viscoelastic Fluids for Oil Recovery, by G. B. Thurston and G. A. Pope. December 1982. 23 pp. 12 figs. The objective of this research was to characterize the viscoelastic behavior of the fluids used in enhanced oil recovery by chemical flooding methods. By a better understanding of the rheological properties controlling porous media flow, more reliable and efficient design can be achieved and more economical oil recovery can be attained. Two polymers, a xanthan gum having a molecular weight near 2×10^6 Daltons and a hydrolyzed polyacrylamide, were selected for application to a variety of rheological evaluations and porous media flow tests. The most conspicuous difference was that the hydrolyzed polyacrylamide showed pronounced dilatancy in porous media flow while the xanthan gum did not. Cross linking in situ was evaluated for the polyacrylamide. Research done under grant G1115481 by the University of Texas at Austin. Available for reference at National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 23-83. Processing of Mineral Fines by Column Flotation, by K. V. S. Sastry. November 1982. 35 pp. 14 figs. A complete understanding of the flotation process in columns is necessary for establishing their design and operational basis and for demonstrating the potential of separation improvements that can be achieved. A research program directed toward an experimental and theoretical investigation of the processing of mineral fines by column flotation is currently underway. Specific aspects of the research program include (1) establishing the range of particle sizes over which column flotation would be most effective, (2) determining the influence of operating variables and their relation to the mineral properties on the overall efficiency of flotation columns, and (3) identifying necessary improvements in flotation column design and investigating the effectiveness of the new design. Experiments were performed using glass beads in various size ranges, and the behavior of the column was evaluated in terms of air and water holdup profiles, particle concentration profile, and flotation recovery. Research done under grant G5105014 by the University of California. Available for reference at Bureau of Mines facilities in Avondale, MD, and Twin Cities, MN; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 24-83. Fracture Mechanics and Structural Response Investigations Associated With Energy Resource Recovery, by S. H. Advani, V. H. Kenner, and T. G. Richard. Dec. 15, 1982. 97 pp. 45 figs. Experimental and theoretical investigations pertinent to fracture mechanics and structural modeling associated with energy resource recovery are reported. The experimental studies include the mixed mode as well as crack opening mode fracture toughness characterization of Pennsylvanian age shales as a function of moisture content. The analytical studies include (1) the stress and subsidence analysis of mine systems, (2) coal hydraulic fracture studies with bi-material response evaluation, (3) tailored pulse loading studies, and (4) constitutive modeling. Research done under grant G1115393 by Ohio State University. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, and Pittsburgh, PA; Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC; and Office of the Assistant Director—Mining Research, U.S. Bureau of Mines, Washington, D.C. Copies of this report will not be available for purchase.

OFR 25(1)-83. Monitoring and Modeling of Shallow Ground Water Systems in the Powder River Basin. Volume I, by Donald Koch, Charles D. Ringrose, Richard C. Moore, and David L. Brooks. July 1982. 358 pp. 85 figs. The project investigated regional impacts of mining on the ground water system of the Powder River Basin by (1) establishment of a regional ground water monitoring network and (2) development of a set of digital computer models to simulate ground water flow and quality, ground water contributions to surface water flow and quality (i.e., baseflow), and watershed runoff and recharge. Over 100 wells were monitored for physical and chemical parameters. Data were used as input to the models and for the development of a comprehensive data base. The basin was modeled on a regional and a subregional scale. Two watershed

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models were evaluated for their ability to provide runoff and recharge inputs to the basic ground water model. Application of the regional and sub-regional models using conservative mining scenarios showed that drawdowns may extend west from the mines as far as 10 miles but that impacts would be insignificant on a regional scale. The watershed model could be effectively applied to small watersheds only. Volume I describes in detail the work performed and the results obtained. Research done under contract J0265050 by Hittman Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC; and Office of the Assistant Director—Mining Research, U.S. Bureau of Mines, Washington, DC. Copies of this report will not be available for purchase.

OFR 25(2)—83. Monitoring and Modeling of Shallow Ground Water Systems in the Powder River Basin.

Volume II. Appendices, by Donald Koch, Charles D. Ringrose, Richard C. Moore, and David L. Brooks. July 1982. 698 pp. 109 figs. The project investigated regional impacts of mining on the ground water system of the Powder River Basin by (1) establishment of a regional ground water monitoring network and (2) development of a set of digital computer models to simulate ground water flow and quality, ground water contributions to surface water flow and quality (i.e., baseflow), and watershed runoff and recharge. Over 100 wells were monitored for physical and chemical parameters. Data were used as input to the models and for the development of a comprehensive data base. The basin was modeled on a regional and subregional scale. Two watershed models were evaluated for their ability to provide runoff and recharge inputs to the basic ground water model. Application of the regional and subregional models using conservative mining scenarios showed that drawdown may extend west from the mines as far as 10 miles but that impacts would be insignificant on a regional scale. The watershed model could be effectively applied to small watersheds only. Volume II contains the data collected during the course of the project, as well as the source codes for the models developed. Research done under contract J0265050 by Hittman Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C.; and Office of the Assistant Director—Mining Research, U.S. Bureau of Mines, Washington, DC. Copies of this report will not be available for purchase.

OFR 26(1)—83. Data Collection and Mathematical Modeling for Predicting Underground Mine Water Inflow. Volume I, by R. Williams, G. Bloomsburg, G. Winter, and D. Ralston. August 1982. 330 pp. 114 figs. The objective of this study is to evaluate the hydrologic variables associated with surface and ground water systems that affect the inflow of ground water into an underground mine. Data collection techniques are reviewed for their applicability for quantifying these hydrologic variables.

Innovative techniques are also investigated. Existing analytical and numerical procedures for predicting underground mine water inflow are reviewed and evaluated. Research done under contract J0100013 by Williams-Robinette and Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; U.S. Department of Energy, Pittsburgh, PA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-171108; paper copy price code A15.

OFR 26(2)—83. Inflow to Horizontal Drains in Tailings Embankments, by R. Williams, G. Bloomsburg, and G. Winter. August 1982. 53 pp. 19 figs.

A technique was developed to determine the length and spacing between horizontal drain pipes to be installed in a tailings embankment through the use of the finite element model UNSAT2. The analysis is based on the combined output of a vertical planar mesh and a horizontal planar mesh. The slot opening in the drain pipe and the length of the perforated section are determined from an analogy to water well design. The pipe diameter and gradient can be determined from Manning's equation. Research done under contract J0100013 by Williams-Robinette and Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; U.S. Department of Energy, Pittsburgh, PA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-178749; paper copy price code A04.

OFR 27—83. Further Studies on Optimum Combined Fire Retardant/Preservative Treatments and Stench

Warning Systems for Wood Mine Timber, by Mark Davis, William Holley, and W. Robert Diehl. May 1982. 82 pp. 11 figs. As a follow-on to previous investigations, reduced treatment levels for the optimum fire retardant-preservative system were evaluated. An impregnation of 3.5 lb/ft³ of Fyreprufe followed by 3.5 mils of Albi 107A plus an Albi 144 top coat provides adequate flammability and flame spread protection. However, there is a significant loss in compressive strength at this retention level, particularly parallel to the grain. A pilot-size pressure impregnation cell was installed for use in treating larger quantities of wood. Based on the optimum fire retardant-preservative treatment system, a model treatment process was developed capable of handling 3 million board feet per year. Associated annual costs per thousand board feet for treating 12- by 12-in timber were calculated. A literature search was conducted to identify materials and techniques suitable for a localized stench warning system for heated mine timbers. Based on this review, several stench warning concepts were developed. Those based on surface coating were

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given a preliminary laboratory evaluation. Research done under contract J0166068 by Springborn Laboratories, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; U.S. Department of Energy, Pittsburgh, PA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-171975; paper copy price code A05.

OFR 28-83. Development of Improved Seatbelt Systems for Surface Mining Equipment, by L. E. Carlson and A. G. Hoffman. Oct. 30, 1981. 127 pp. 4 figs. Tasks required in the development of improved seatbelt systems included a literature and information search, development and test of a prototype seatbelt system, production of field test systems, field tests, and evaluation of the field test results. The systems were a retractable sheath design with both automatic and manual locking features. Results indicate mining equipment operator acceptance of seatbelts were enhanced by the design features of the improved systems. Research done under contract H0202005 by the Mobility System and Equipment Co. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-171991; paper copy price code A07.

OFR 29(1)-83. High Angle Conveyor Study. Volume I, by E. A. Mevissen, A. C. Siminerio, and J. A. Dos Santos. December 1981. 294 pp. 93 figs. With the ever-increasing consumption of mineral commodities, the vital question is not whether sufficient mineral quantities will be available, but rather can the known existing low-grade resources be mined economically. Conventional conveyor systems are being used in some open pit mines to decrease haulage costs. This report presents cost analyses that were performed on hypothetical copper, taconite, and phosphate mines. Available high-angle conveying equipment is identified, and the haulage and crushing costs associated with a conventional truck and shovel mining operation and a high-angle conveyor operation are examined. Information was gathered from a series of high-angle conveying equipment and open pit mining operations in the United States. Volume I includes a detailed review of the state of the art in high-angle conveying concepts, the hypothetical mine development, and the cost analyses. Research done under contract J0295002 by the Dravo Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; U.S. Department of Energy facilities in Pittsburgh, PA, and Morgantown, WV; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order

ONLY from NTIS: PB 83-175042; paper copy price code A13.

OFR 29(2)-83. High Angle Conveyor Study. Volume II, by E. A. Mevissen, A. C. Siminerio, and J. A. Dos Santos. December 1981. 279 pp. 2 figs. This report presents the cost analyses on hypothetical copper, taconite, and phosphate mines. Information was gathered from a series of high-angle conveying equipment and open pit mining operations in the United States. Volume II includes the appendices. Research done under contract J0295002 by the Dravo Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; U.S. Department of Energy facilities in Pittsburgh, PA, and Morgantown, WV; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-175059; paper copy price code A13.

OFR 30-83. Phone Line Signal Propagation in Coal Mines, by Terry S. Cory. August 1981. 178 pp. 114 figs. This report describes the results of a measurement program to determine the broad spectral characteristics of both differential and common mode noise on phone lines in three coal mines and signal attenuation spectral characteristics on the same broad basis over phone line strings with taps and/or branches. The frequency range used was a baseband of 1,000 kHz for resolution bandwidth ranging from 100 Hz near baseband to 30 kHz near 1 MHz. The signal attenuation measurements were performed on all three "legs" of taps where possible and applicable. Results were obtained comparing shielded and unshielded phone lines in one mine. The results include an improved electromagnetic noise chart for coal mines showing variations with types of mines, topology, and location of noise sources. Fundamental high-frequency limit on untreated phone lines in coal mines is identified. Research done under contract J0308095. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-171637; paper copy price code A09.

OFR 31(1)-83. Floodplain Disposal of Mill Tailings. Volume I-Text, by K. E. Robinson, B. E. McKee, and M. M. Eivemark. October 1981. 67 pp. 15 figs. Volume I of this two-volume report provides an initial indication that mill tailings produced in the Coeur d'Alene mining district of Idaho can be placed on floodplain areas in a technically acceptable manner without artificial liners and without seriously contaminating the surrounding area. Tests have shown that landfills on these unused areas can result in returning the areas to productive use. Among the environmental considerations in using tailings for landfill construction are acid and other contaminations produced by tailings and wind erosion of exposed tailings

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surfaces. The results indicate that adverse impacts are not as severe as previously thought and that mitigative measures are feasible. Based on the preliminary data, and in accord with Federal and State waste management regulations, a conceptual design was developed for 23 potential landfill sites in the district that could reclaim 750 acres of floodplain. A cost analysis of landfill construction with mill tailings indicates that the method would be an economically viable means for increasing the valley-wide tailings storage capacity, provided construction with slurried tailings is feasible. Research done under contract J0188146 by Robinson Dames & Moore and Greater Shoshone County Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-170779; paper copy price code A04.

OFR 31(2)-83. Floodplain Disposal of Mill Tailings. Volume II—Appendices A-F, by K. E. Robinson, B. E. McKee, and M. M. Eivemark. October 1981. 242 pp. 152 figs. This study provides an initial indication that mill tailings produced in the Coeur d'Alene mining district of Idaho can be placed on floodplain areas in a technically acceptable manner without artificial liners and without seriously contaminating the surrounding area. Volume II of this two-volume report contains appendices A through F. The report includes (1) the results of a study that evaluates the feasibility of disposing of mill tailings by landfill construction, (2) a description of a field and laboratory testing program that assesses the effectiveness of a soil liner as a means of seepage control, (3) a summary of a thesis on the analysis of acid production potential and the results of geotechnical testing of mill tailings, (4) a description of potential landfill sites and their development to meet the present needs of the mining industry and the future requirements of the community, (5) a description of the legislation impacting on tailings disposal, and (6) a discussion of the environmental and socioeconomic factors that should be considered. Research done under contract J0188146 by Robinson Dames & Moore and Greater Shoshone County Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-170787; paper copy price code A12.

OFR 32(1)-83. Safety Analysis of the Blind Shaft Borer. Volume 1. Summary Report, by C. A. Geffen-Fowler. July 1981. 77 pp. 7 figs. This report presents the results of an examination of the safety of the blind shaft borer (BSB) shaft sinking system and an alternative modified BSB design concept in comparison with conventional shaft sinking technology. Detailed study of the two systems was performed to identify and recommend design

changes for optimum safety conditions. A comparison of the BSB system with conventional shaft sinking was made on the basis of relative risk levels, which includes both the frequency and the potential consequence of accidents. A safety evaluation of the component operations of the two BSB systems was performed using a failure modes and effects analysis methodology. The results of this analysis show generally that both BSB systems are safer than conventional shaft sinking. The potential risk of conventional shaft sinking operations could be reduced by over 30% with the use of the original BSB system, and by about 10% with the modified BSB system. Design change recommendations to further improve the safety of these systems include a better fire suppression system, improved worker haulage systems, and more compact hydraulics. An operational safety manual was also developed for the modified BSB system. Research done under contract J0295050 by Battelle, Pacific Northwest Laboratories. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; U.S. Department of Energy, Pittsburgh, PA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-174284; paper copy price code A05.

OFR 32(2)-83. Safety Analysis of the Blind Shaft Borer. Volume 2. Supplementary Reports A-E, by C. A. Geffen-Fowler. July 1981. 443 pp. 24 figs. This report presents the results of an examination of the safety of the blind shaft borer (BSB) shaft sinking system and an alternative modified BSB design concept in comparison with conventional shaft sinking technology. Detailed study of the two systems was performed to identify and recommend design changes for optimum safety conditions. Volume 2 comprises supplementary reports A through E. Research done under contract J0295050 by Battelle, Pacific Northwest Laboratories. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; U.S. Department of Energy, Pittsburgh, PA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-174292; paper copy price code A19.

OFR 32(3)-83. Safety Analysis of the Blind Shaft Borer. Volume 3. Supplementary Reports F-J, by C. A. Geffen-Fowler. July 1981. 434 pp. 10 figs. This report presents the results of an examination of the safety of the blind shaft borer (BSB) shaft sinking system and an alternative modified BSB design concept in comparison with conventional shaft sinking technology. Detailed study of the two systems was performed to identify and recommend design changes for optimum safety conditions. Volume 3 comprises supplementary reports F through J. Research done under contract J0295050 by Battelle, Pacific Northwest Laboratories. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, Co, Avondale,

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MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; U.S. Department of Energy, Pittsburgh, PA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-174300; paper copy price code A19.

OFR 32(4)-83. Safety Analysis of the Blind Shaft Borer.

Volume 4. Safety Manual, by C. A. Geffen-Fowler. July 1981. 105 pp. 5 figs. This report presents the results of an examination of the safety of the blind shaft borer (BSB) shaft sinking system and an alternative modified BSB design concept in comparison with conventional shaft sinking technology. Detailed study of the two systems was performed to identify and recommend design changes for optimum safety conditions. Volume 4 contains the safety manual. Research done under contract J0295050 by Battelle, Pacific Northwest Laboratories. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; U.S. Department of Energy, Pittsburgh, PA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-174318; paper copy price code A06.

OFR 33-83. Fluid Cavitation as a Rock Crushing and Rock

Fragmentation Tool, by David A. Summers and Marian M. Mazurkiewicz. December 1982. 94 pp. 36 figs. The use of high-pressure fluid cavitation is investigated as a means of breaking an ore into its constituent grains. This cavitation rock disaggregation (CRD) is found to be possible and effective in breaking down galena ore, both in sandstone and dolomite host material. The technique did not work as well in comminuting and cleaning oil shale because the cavitation drove the oil into emulsion with the water. The presence of dominant bedding in the rock also caused preferential breakage to these lines rather than to the individual grain boundaries. This problem was also encountered in tests on igneous ore where weakness planes of the overall ore proved weaker than the boundaries of the individual grains. The prevailing expression of cavitation erosion dependence on pressure was not found to be absolutely valid. In contrast, CRD was found to be much more sensitive to jet flow diameter, and when this was recognized, it was found possible to erode with compressive strength of up to 350 MPa with operating jet pressures of 40 MPa. Research done under grant G1115291 by University of Missouri—Rolla. Available for reference at the Bureau of Mines facilities in Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Spokane, WA, and Office of the Assistant Director—Mining Research, U.S. Bureau of Mines, Washington, DC. Copies of this report will not be available for purchase.

OFR 34-83. Determination of the Washability and Flotation Characteristics of Missouri Coal Seams, by M.

Hayri Erten. Sept. 30, 1982. 158 pp. 44 figs. The objectives of this research were (1) to draw the washability curves of Missouri coal seams to deter-

mine their washability characteristics, (2) to investigate the possibility of ash and sulfur removal by gravity methods, and (3) to determine the flotation behavior of the seams. During a 2-year period 47 channel and 29 drill-hole samples were received and tested. The samples showed that Missouri coal seams contain high ash and sulfur in the as-received condition. The ash contents of 76 samples tested ranged from 8.30 to 39 percent, whereas the sulfur contents ranged from 0.95 to 14.55 percent. However, the washability tests conducted on —1.00- to —0.25-in channel samples and —0.25-in core samples indicated that 1.40 and 1.50 specific gravity separations, clean coals containing fairly low ash and a total sulfur percentage ranging between 1.02 and 4.69 can be obtained. Research done under grant G1115293 by the University of Missouri—Rolla. Available for reference at Bureau of Mines facilities in Rolla, MO, and Pittsburgh, PA; Office of Assistant Director—Mining, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 35-83. Pilot Study for the Development of Precision Electronic Blasting Delay Detonators Utilizing Self-Contained Integrated Timing Circuits, by Paul Worsey.

Nov. 29, 1982. 67 pp. 7 figs. Apart from being inaccurate, electric blasting caps (detonators) are known to be inherently dangerous with respect to potential accidental initiation. This may be caused by different electric and electromagnetic phenomena such as static electricity, overhead powerlines, ground currents, radio waves, stray currents, and electric storms. However, apart from the risk of accidental initiation, commercial detonators are susceptible to misfire from grounding, short circuit, etc., due to the presence of moisture. Because of the latter two problems, certain manufacturers have begun to change production from electrically initiated detonators to encapsulated explosive tube initiated detonators. Although this new form of non-electrical detonator has none of the quoted potential risks of accidental initiation or misfire, it contains the same type of chemical delay element that is the major cause of inaccuracy in electric delay series blasting caps. The purpose of this work is to combine the old and new technologies and develop a new integrated electronic delay blasting cap that utilizes an electronic microchip as a delay element. Research done under grant G1114028 by the University of Missouri—Rolla. Available for reference at Bureau of Mines facilities in Avondale, MD, and Pittsburgh, PA; Office of Assistant Director—Mining, Bureau of Mines, Washington, DC; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 36-83. Improvement of the Performance of Copper Electrowinning in Fluidized Bed Cells, by J. W.

Evans, M. Dubrovsky, and D. Ziegler. Sept. 30, 1982. 11 pp. 7 figs. Research was done on anodes for use with fluidized bed cathodes for electrowinning copper. Suitable anodes must have low power consumption (less than 3 kilowatt hours per kilogram of copper) while operating at high current densities (several thousand amperes per square meter). The anodes must also be free of operating problems and suitable for scale-up. The research resulted in a cell with energy consumption rates less than in conventional cells up to a current density about 10 times greater than in a conventional

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cell. The anode was tested on both a small, 50-ampere cell and on a larger, 1,000-ampere scale. Auxiliary experiments were carried out on the fluidized bed electrowinning of copper from dilute solutions, from dilute solutions containing cobalt and nickel, and from dilute chloride solutions. Research done under grants G1115061, G1105060, and G1195006 by the University of California at Berkeley. Available for reference at Bureau of Mines facilities in Avondale, MD, Rolla, MO, Reno, NV, and Salt Lake City, UT; at the National Library of Natural Resources, U.S. Department of the Interior, Washington, DC; and Office of the Assistant Director—Mineral and Materials Research, U.S. Bureau of Mines, Washington, DC. Copies of this report will not be available for purchase.

OFR 37-83. Autoclaved Lime-Aluminosilicate Materials for Alumina Extraction and Construction, by Charles A. Sorrell. Sept. 30, 1982. 25 pp. The initial purpose of this project was to investigate reactions between lime and aluminosilicate materials to (1) obtain compounds more susceptible to acid leaching for removal of alumina, titania, or other commercially valuable components, and (2) to develop a cementitious bond strong enough to warrant use of waste materials or inexpensive rock materials for construction materials. It was found that the first objective need not be pursued because it was unnecessary to react many materials prior to acid leaching and that the second objective was not worth pursuing because nothing was found to equal presently available sandlime bricks in terms of strength, durability, or cost. Research done under grant G1115292 by the University of Missouri—Rolla. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, and Salt Lake City, UT; Office of Assistant Director—Minerals and Materials Research, Bureau of Mines, Washington, DC; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 38-83. Characterization of Ohio Limestone To Determine Potential Use in Control of Coal Emissions, by Roger J. Bain. December 1982. 43 pp. 4 figs. Over 200 carbonate rock samples were collected from 33 quarries in Ohio. Quarries were studied and described in detail in order to characterize the nature of the quarry operation, the type of stone being produced, variability in carbonate materials, and the ability to produce a lithologically consistent product. The 200 samples were analyzed by petrographic thin section analysis, scanning electron microscopy, neutron activation, cathode luminescence, X-ray diffraction, sulfur reactivity, chemical analysis, porosimetry, and pore casts. Variations in rock were tested to determine which lithologic features affected reactivity. It was determined that crystallinity, crystal size, porosity, and chemical composition are the major controlling factors. The best sorbent will possess euhedral crystals in the 0.05- to 0.2-mm size range, intercrystalline porosity, and a high calcium content. Dolomites, in general, possess the best texture and several units in Ohio are suitable for use as sorbents. Research done under grants G5105080, G1105080, G1115392, and G5195033 by the University of Akron. Available for reference at the Bureau of Mines Salt Lake City (UT) Research Center; Office of Assistant Director—Minerals and Materials Research, Bureau of Mines, Washington, DC; and National Library of Natural Resources, U.S. Department of the Interior,

Washington, DC. Copies of this report will not be available for purchase.

OFR 39-83. Nursery Techniques for Production of Tree Seedlings Infected With Specific Mycorrhizal Fungi for Surface Mine Reclamation, by James W. Hendrix. Dec. 30, 1982. 45 pp. 2 figs. A survey of endomycorrhizal fungi occurring on orphan coal mine lands in western and eastern Kentucky revealed a great diversity of species present. Thus, a large number of fungi are available for isolation and evaluation for enhancing revegetation of mined lands. Endomycorrhizal fungi isolated from orphan mines stimulated growth of sweetgum seedlings on mine soil at low fertilization but inhibited growth at high fertilization; this growth inhibition at high fertilization did not occur with plants growing on peat-perlite. Banding of endomycorrhizal inoculum was not advantageous, compared with incorporation of inoculum throughout the growth medium, for production of mycorrhizal sweetgum seedlings. Newly reclaimed mine spoils were nearly nonmycorrhizal, compared with land reclaimed 4 or 8 years earlier. A procedure for isolation of single-spore cultures of endomycorrhizal fungi was developed; this is necessary for ecotypic variability. A practical procedure using container-grown *Pisolithus tinctorius*-infected shortleaf pine seedlings for production of large numbers of bareroot pine seedlings infected with *P. tinctorius* for mined land reclamation was demonstrated. Research done under grants G1105004, G1115003, and G1115212 by the University of Kentucky. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Salt Lake City, UT, and Spokane, WA; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 40-83. Wireless Communications for Trackless Haulage Vehicles, by Terry S. Cory. July 1979. 164 pp. 51 figs. This report describes a complete system design methodology for medium frequency (MF) wireless radio systems for use in coal mines. The emphasis is on ac mines where no trolley wire exists and for which conventional trolley phone communications cannot be used. The report constitutes an MF system design handbook and includes a compendium of all previous MF technology elements as well as a reference index with abstracts of all pertinent literature. Research done under contract J0395072. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-171744; paper copy price code A08.

OFR 41-83. Laboratory Evaluation of Janelid Method of Dead Heading Ventilation, by A. Erickson and K. Heller. August 1981. 56 pp. 17 figs. The effectiveness of a loader-mounted fan on diesel vehicles combined with natural convection for ventilation of a dead heading ventilation system was investigated. The results were obtained using CO₂ as a tracer gas in a ¼-scale model heading. Buoyant forces were scaled to establish similarity with full scale. For a loader moving in a typical load-haul-

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dump cycle, the loader-mounted fan reduced the tracer gas concentration by 26 percent compared with a reduction of 32 percent for a jet fan of four times the flow capacity. Research done under contract J0395016 by Foster-Miller Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; U.S. Department of Energy in Pittsburgh, PA, and Morgantown, WV; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-171959; paper copy price code A04.

OFR 42-83. In Situ Shear Strength of Rock in Open Pit Benches (Development of Equipment and Field Procedures), by M. K. McCarter and L. R. Partington. August 1982. 173 pp. 54 figs. This project involves the construction and field testing of a large borehole jack designed to operate within a conventional 12 1/4-inch rotary blasthole common to open pit mining. The system is capable of exerting approximately 800,000 pounds on curved platen measuring about 4 by 24 inches. Field tests indicate that the system will operate in a mining environment, and preliminary results suggest the possibility of using the force-displacement data generated by the jack to rank the competency of material within a mine bench. Research done under grant G1195048 by the University of Utah. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Office of Assistant Director—Mining, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-171736; paper copy price code A08.

OFR 43-83. Reclamation of Mined Peatlands, by R. S. Farnham. March 1982. 20 pp. 3 figs. Peat is partially decomposed plant material that has accumulated in a saturated environment. Peatlands are located in depressional areas, large sloping lake plains, or any area in which the topography, climate, and hydrology produce an oxygen-deficient environment limited to microbial decomposition. The mining of this material for horticultural peat and energy production has taken place for the past several decades in several European countries and information gathered from past reclamation research on these lands is cited in this report. This project addresses the problems associated with the agricultural reclamation of these mined lands. Peatland drainage, fertility, and field preparation as well as crop selection for these areas is discussed. Laboratory, greenhouse, and field evaluations of representative Minnesota peats are included in the report. Data derived from these investigations suggests that the low natural fertility and short growing season of peatland areas are the major limitations to reclamation. Relatively large amounts of potassium and phosphorus fertilizers and some micronutrient additions are required on peatlands to obtain proper plant growth. It was found that the cole crops (broccoli, cauliflower, cabbage) and short season agronomic crops are suitable on Minnesota peatlands. Research done under contract J0205044 by the University of Minnesota. Available for reference at Bureau of Mines facilities in Tus-

caloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-172007; paper copy price code A02.

OFR 44-83. Propose and Evaluate Methods of Controlling Mercury Vapor Emissions in a Processing Mill Furnace Room, by Paul T. Bartlett and Terry L. Muldoon. July 1982. 115 pp. 29 figs. The objective of this program was to develop cost-effective methods of controlling mercury vapor in a processing mill furnace room with particular emphasis on the McDermitt mercury mill in Nevada. Process, environmental, and operating data were collected at McDermitt and a preliminary evaluation of control systems was performed. Efforts were focused on the furnace, which is the primary mercury emission source, and furnace positive pressure or "blowback," which is the cause of the greatest furnace emissions. Cost-effective conceptual design alternatives were prepared that addressed the identified emissions problems, particularly furnace blowback. Two designs were selected and detailed design drawings and cost estimates were prepared. The first design agglomerates the filter cake upstream of a belt conveyor, which replaces the existing screw conveyor. The second design dries the filter cake to 5 percent moisture before conveyance on the belt conveyor. Both designs are expected to reduce mercury vapor concentrations by more than 500 $\mu\text{g}/\text{m}^3$ in the furnace building and approximately 160 $\mu\text{g}/\text{m}^3$ in the concentrator building during furnace operations. Research done under contract J0318024 by Foster-Miller Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-171751; paper copy price code A06.

OFR 45-83. Evaluating the Impact of Prospective Changes in Materials Use: An Input-Output Approach, by Wassily Leontief, Michael Bever, James C. M. Koo, and Ira Sohn. December 1982. 83 pp. The purpose of this study was to investigate the economic impact of prospective changes in materials use in the U.S. motor vehicle, household furniture and appliances, beverage packaging, and highway and street construction industries under alternative scenarios. The impact of increased imports of automobiles and a changing recycling rate of nickel was also examined. Under assumed economic growth rates and structural changes in the U.S. economy, projections of output and consumption levels of selected industries and level of nonfuel minerals to 2000 were computed. Chapter I of the report addresses the applicability of input-output techniques followed by a detailed description of the structure of the model in Chapter II. Chapter III discusses the economic growth assumptions of the United States to 2000 as well as data and assumptions used in designing each of the eight scenarios included in the study. Results, analyses, and conclusions of each scenario are presented. Research done under contract J0188147 by the Institute of Economic Analysis, New York Univer-

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sity. Available for reference at Bureau of Mines facilities in Juneau, AK, Denver, CO, Pittsburgh, PA, and Spokane, WA; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-170845; paper copy price code A05.

OFR 46-83. Improved Fire Protection System for AN-FO Haulers and Loaders, by Bruce Christensen, Steven Hunter, and Lyle McDonald. June 30, 1980. 215 pp. 59 figs. The objectives of this investigation are to (1) conduct a fire hazards analysis of all AN-FO haulers and loaders and (2) to develop and demonstrate an automatic fire sensing and suppression system for this class of surface mining machinery. The research included (1) data acquisition through visits to nine mine sites, two AN-FO hauling contractors, two equipment manufacturers, and a literature search. (2) Analysis of accumulated data providing specific design inputs for an AN-FO hauler representing the greatest overall fire hazard, operating conditions, previous fire experiences and performance, cost, and maintenance factors affecting potential purchases of automatic fire control systems for AN-FO haulers and loaders. (3) Development of a recommended design concept for a low-cost and reliable fire protection system. A specific system design was developed based on the data analysis and system specifications were determined. Factory testing of the fire protection system components included a full-scale fire test of the system on an AN-FO vehicle mock-up. Installation of the prototype system on an AN-FO vehicle at a surface coal mine and a demonstration of performance by fire tests were performed. Research done under contract H0282015 by The Ansul Co. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Health and Safety Academy, Beckley, WV; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-170704; paper copy price code A10.

OFR 47(1)-83. Ecological Studies on the Revegetation Process of Surface Coal Mined Areas in North Dakota. 1. Executive Summary, by Mohan K. Wali. June 1982. 35 pp. This report, the first in a series of 13, provides a summary of 11 major topics on which individual reports have been prepared. The topics include (1) nature of coal mine spoils, topsoils, and unmined soils; (2) influence of macro- and microclimate on biomass; (3) plant production on spoils and topsoils; (4) prediction of aboveground biomass from plant cover; (5) mineral composition of plants; (6) controlled environment studies on plant growth response; (7) microbial communities; (8) water chemistry and organism diversity of catch-basins; (9) vegetation and soil development on abandoned sites; (10) vegetation and soil development on topsoiled sites; and (11) viability and diversity of seed banks. Based on these investigations, general conclusions and some recommendations are presented. Research done under contract J0295015 by the University of North Dakota. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and Office of Surface Mining Library and National Library of Natural Resources,

U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-171322; paper copy price code A03.

OFR 47(2)-83. Ecological Studies on the Revegetation Process of Surface Coal Mined Areas in North Dakota. 2. Physical and Chemical Properties of Overburden and Topsoils as Affected by Time and Amendments, by Nirander M. Safaya, Richard H. Bares, Nunna Malakondaiah, and Stuart A. Nicholson. June 1982. 180 pp. 88 figs. Field experiments were conducted at six coal mine sites in Oliver and Mercer Counties, ND, to determine the subsequent effects of a single application of selected amendments on spoil and topsoils over the 5-year period, 1974-78. Considerable variations in the physical and chemical properties were found in mine spoils from site to site. The texture of spoils ranged from sandy clay loams to loamy sands. The pH of the sites ranged from 6.5 to 8.2. In many cases, the pH values of mine spoils were not significantly different from the topsoils. The electrical conductivity did not exceed 6 mmhos cm^{-1} at the test sites even though in other studies much higher values were recorded in the vicinity. The spoils can be classed as moderately saline to nonsaline. The sodium adsorption ratios (SAR) ranged from less than 1 to 32, with the lowest SAR values in the topsoiled sites. Some of the spoils were highly calcareous. The spoils that were the least calcareous showed the calcium carbonate equivalent three times higher than that of the topsoil. Research done under contract J0295015 by the University of North Dakota. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-171330; paper copy price code A09.

OFR 47(3)-83. Ecological Studies on the Revegetation Process of Surface Coal Mined Areas in North Dakota. 3. Soil and Vegetation Development of Abandoned Mines, by Mohan K. Wali and Richard H. Pemble. June 1982. 99 pp. Soil and vegetation development were studied on abandoned mine sites in Ward County, ND. The sites studied were 1, 7, 17, 30, and 45 years old since abandonment; unmined sites were also studied to provide measures of comparison. Species diversity was the highest at unmined sites and lowest at the 1-year-old site; sites 7, 17, 30, and 45 years old had 37, 52, 43, and 68 species, respectively. Stand ordination revealed that site ages were the most important in influencing species diversity and composition. Stand-environmental complex ordinations encompassing 53 variables showed topographic variables to be the most important followed by site ages. Species distributional diagrams are provided to show habitat preferences that may be helpful in formulating species prescriptions for revegetation. Research done under contract J0295015 by the University of North Dakota. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-171348; paper copy price code A05.

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OFR 47(4)-83. Ecological Studies on the Revegetation Process of Surface Coal Mined Areas in North Dakota. 4. Soil and Vegetation Development on Topsoiled Areas, by Louis R. Iverson and Mohan K. Wali. June 1982. 68 pp. 12 figs. Four North Dakota reclaimed mined sites 1 to 4 years old were studied for patterns of species colonization, biochemical interaction among species, competitive phenomena, and management applications. *Kochia scoparia*, a colonizer, was the dominant species for the first 2 years, but was completely eliminated by the fourth year; the planted *Agropyron* grasses concomitantly increased during the 4-year period. Chemical analysis of the soils over the same period showed decreases in several soluble elements due to leaching and a slight buildup of nitrogen and organic matter. Competition experiments between *Kochia* and *Agropyron* revealed that *Kochia* initially acted as a "nurse" crop for *Agropyron* establishment, but later in the first season began to shade excessively, reducing *Agropyron* tillering. Studies on the plant population biology of *Kochia* showed that it conformed well to several established laws governing yield versus density relationships. Field and growth chamber experiments revealed that decaying *Kochia* leaves and roots were toxic to *Kochia* growth and were partially responsible for the rapid demise of the species. Chemical analysis of the soils and plant tissues indicated nutritional imbalances may be responsible for the autotoxicity. Another bioassay experiment implicated allelochemicals to be important in several other colonizing species. Mowing the first year colonizing species just prior to seed set proved to be effective in reducing weed populations and improving planted *Agropyron* populations in the second year. Research done under contract J0295015 by the University of North Dakota. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-171355; paper copy price code A04.

OFR 47(5)-83. Ecological Studies on the Revegetation Process of Surface Coal Mined Areas in North Dakota. 5. Plant Production on Spoils and Topsoils as Affected by Time and Amendments, by Richard H. Bares. June 1982. 67 pp. 14 figs. Field study sites were established on recontoured mined areas during the early 1970's in which several amendments were tested for their ability to improve spoil-topsoil conditions and, hence, increase plant production. A number of grass and legume species combinations were studied. The general effects of one-time, single-rate application of Leonardite and/or slack coal to spoils and topsoils was the reduction of grass dry matter yields and the promotion of legume establishment and yield. Production of weedy species was remarkably lower on topsoil treated with Leonardite than that without Leonardite. The general effect of commercial fertilizer applied one time prior to seeding was to increase plant production during the first 2 to 3 years after which the effect disappeared; the effect was much more pronounced on spoils. Weedy species accounted for most of the biomass production during the first growing season. Research done under contract J0295015 by the University of North Dakota. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany,

OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-171363; paper copy price code A04.

OFR 47(6)-83. Ecological Studies on the Revegetation Process of Surface Coal Mined Areas in North Dakota. 6. Relationship Between Cover and Aboveground Biomass, by Diana K. Schimmelpfennig. June 1982. 52 pp. 5 figs. A study was done to evaluate the predictability of aboveground biomass production on revegetated mined sites and adjacent native prairies using plant cover estimates made with the point frame method. The predictability of biomass production by cover estimates bears on the need for measurements of both plant cover and aboveground biomass in assessing revegetation success. A positive, statistically significant correlation was demonstrated between plant cover (estimated by the point frame method) and aboveground biomass (estimated by the harvest method) regardless of community type (mined or native), species composition, diversity, or level of biomass production. However, the latter did have their effects on the relationship and must be accounted for in any predictive equations; that is, the predictive equations must be considered site specific. Research done under contract J0295015 by the University of North Dakota. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-171371; paper copy price code A04.

OFR 47(7)-83. Ecological Studies on the Revegetation Process of Surface Coal Mined Areas in North Dakota. 7. Mineral Analysis of Plants Grown on Spoils and Topsoils, by Nunna Malakondaiah. June 1982. 46 pp. Plant samples collected from mined and test sites in surface coal mined areas of North Dakota were analyzed for nutrient concentrations. The vegetation from the mined areas generally showed lower concentrations of Na, P, and Cu and failed to meet the nutritional requirements for beef cattle as defined by the National Research Council. Some plants showed generally higher concentrations than others, and lower concentrations of P were reported in most of the plants on some unmined sites. Amending the spoil with slack at one test site decreased the concentrations of Zn, Cu, and P in wheatgrasses grown on spoil from 0- to 2-, 5- to 10-, and 20- to 25-foot depths, respectively. Leonardite amendment at one test site decreased P concentration in grasses compared with control, whereas fertilizer increased the same. The concentrations of Ca, Mg, Na, Fe, Cu, and N in grasses were significantly higher on topsoil than at slack-amended spoil at one test site. The data presented in this report act only as an indication of between-treatment and between-species differences in tissue composition of plants harvested in midsummer season. Since none of the nutrients analyzed were found toxic, the cattle can safely feed on the mined land vegetation. Research done under contract J0295015 by the University of North Dakota. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT,

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and Spokane, WA; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-171389; paper copy price code A03.

OFR 47(8)-83. Ecological Studies on the Revegetation Process of Surface Coal Mined Areas in North Dakota. 8. Soil Algae, by Thomas L. Starks and L. Elliot Shubert. June 1982. 75 pp. 11 figs. Surface soil and topsoil samples from experimental test sites in western North Dakota were aseptically collected during August 1975 and from May through September during 1976-77. Selected samples were cultured in a defined inorganic medium and after 6 weeks the algae were identified. Chlorophyll *a* content of the soil and spoil was used as a measure of the algal abundance. Soil physical-chemical properties, species variety, and abundance were statistically analyzed. All test sites revealed distinct soil algal communities and demonstrated a successional trend as evidenced by significant increases in species variety and biomass over time. Some soil factors (Ca, Cu, and P) affected species variety and abundance at more than one site. Others were important at specific sites (Si and Al at one site; Mn, Na, and Zn at another site; and B, Cd, and Mg at another site). Topsoiled areas had higher species varieties and abundances when compared with control areas, as did plots treated with amendments such as Leonardite and fertilizer. Research done under contract J0295015 by the University of North Dakota. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-171397; paper copy price code A04.

OFR 47(9)-83. Ecological Studies on the Revegetation Process of Surface Coal Mined Areas in North Dakota. 9. Viability and Diversity of the Seed Bank, by Louis R. Iverson and Laura Brophy. June 1982. 43 pp. 7 figs. Analysis of seed numbers present in topsoils indicated that seeds of the most prevalent colonizers were not present in the topsoil in a grazed area, an ungrazed area, and two stockpiles upon respreading but rather reappeared by immigration from the surrounding areas. The grazed site had a seed density of over 7,700 seeds per m² and the ungrazed site had 3,900 seeds per m²; the stockpiled topsoils had very low seed densities (225 and 520 seeds per m²). Seed densities and diversity decreased with depth on both the grazed and ungrazed sites; this was especially true on the grazed site where 94% of the seeds were found in the surface 7.5 cm. Several species were present in the seed bank that were also found on the 3- and 4-year-old mined sites in the aboveground vegetation survey. Seeds from these species may germinate after several years of dormancy, thereby starting populations on mined sites and enhancing plant diversity. Seed bank analysis was also undertaken on mined sites ranging from 2 to 6 years old and on an unmined site. Mined site seed densities ranged from 1,630 to 3,980 seeds per m²; the 4-year-old site had the greatest density and the unmined site and stockpiled topsoil sample had lower seed densities. A significant positive correlation between total viable seed content and soil-water saturation percentage indicated that soil texture may influence seed via-

bility-dormancy; there was poor correlation between the aboveground flora and the belowground seed composition. Research done under contract J0295015 by the University of North Dakota. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-171405; paper copy price code A03.

OFR 47(10)-83. Ecological Studies on the Revegetation Process of Surface Coal Mined Areas in North Dakota. 10. Elements of Macro- and Microclimate, by Richard H. Bares. June 1982. 61 pp. 13 figs. The general or macroclimate of the study site in western North Dakota is characterized by rapid and sometimes extreme daily and day-to-day temperature fluctuations, rainfall patterns that are erratic in spatial and temporal distribution and intensity, generally low relative humidity, plentiful sunshine, nearly continuous air movement, and a relatively short frost-free period. Of particular relevance to plant growth and productivity is the mosaic of microclimates that are affected by landform; exposure; slope angle, length, and aspect; and soil color, texture, and surface and vegetation cover. The most critical plant growth-governing factor is available water. It is determined principally by water input (precipitation) and water loss (evapotranspiration), which is increased by high temperatures, wind, and poor surface and vegetation cover. While spring and fall precipitation is generally gentle and soil-soaking, summer rains frequently come in the form of intensive, soil-washing, localized convective thunderstorms of short duration. Due to the convective nature of these storms, summer rainfall is particularly affected by regional topography; southwest slopes and crests often receive more rainfall since the storms usually move in a northeasterly direction. The water loss due to runoff and consequent soil erosion are major problems resulting from such "cloudbursts." Previous fall precipitation in September and October, when added to the current seasonal precipitation from March through August, was found to be significantly correlated with plant production. Generally clear skies over the region facilitate receipt of abundant sunshine at the earth's surface. While good for early season soil warming and plant photosynthesis, this abundant sunshine coupled with long days and nearly continuous wind is responsible for evapotranspiration exceeding precipitation by an average of 6 inches between June and September. On a local scale, the water deficit is most severe on the southern exposures, which receive the most direct solar radiation and therefore are warmer than other exposures. Research done under contract J0295015 by the University of North Dakota. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-171413; paper copy price code A04.

OFR 47(11)-83. Ecological Studies on the Revegetation Process of Surface Coal Mined Areas in North Dakota. 11. Effect of Amendments on Soil-Plant-

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Nutrient Relations Under Controlled Conditions, by Nunna Malakondaiah and Nirander M. Safaya. June 1982. 64 pp. 2 figs. Several growth chamber and laboratory experiments were conducted to study the germination behavior of plant species on mine spoils and plant growth responses to nutrients on spoils and topsoils. Experiments were conducted to study the germination potential of some native and introduced species under various conditions. The seeds of green needlegrass, side oats grama, thickspike wheatgrass, crested wheatgrass, birdsfoot trefoil, and emerald crownvetch were less tolerant, whereas those of alkali sacaton, durar hard fescue, slender wheatgrass, yellow sweetclover, and alfalfa were most tolerant to the sodic mine spoil conditions. Addition of leonardite improved the germination potential of some of the poor germinators. Slender wheatgrass and yellow sweetclover were used as test plants to study the fertility status and productivity potential of stockpiled topsoils and spoils collected. The topsoils were neither saline nor sodic but low in N and P; the spoils were neutral to alkaline. Application of N and P together to the topsoils increased the yield of wheatgrass and sweetclover by 88% to 70% of their respective maximum yields, whereas near maximum yields were obtained for both species by the same treatments to the spoils. The average yields on topsoils were higher than the yields on spoils. The concentrations of major nutrients were higher in plants grown on topsoil, whereas the opposite was true with concentrations of Mn, Zn, and Cu. Growth chamber experiments were conducted to study the growth responses of alfalfa, oats, and slender wheatgrass by the application of Mn and Zn to a sodic coal mine spoil that was previously used for pot culture experiments. Significant growth responses to Mn and Zn were observed in alfalfa but not in oats or slender wheatgrass. Fertilizing the spoil with Mn along with NPK increased the yield of alfalfa to 85% and with Mn plus Zn to 99%. Growth responses and plant composition results of this study confirm that the application of major nutrients to spoils can accentuate Zn and Mn deficiencies in some plants. Research done under contract J0295015 by the University of North Dakota. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-171421; paper copy price code A04.

OFR 47(12)-83. Ecological Studies on the Revegetation Process of Surface Coal Mined Areas in North Dakota. 12. Screening Plants for Phosphorus Requirements, by Nirander M. Safaya and Nunna Malakondaiah. June 1982. 49 pp. 2 figs. Several plant species were screened using continuous-flow and spoil culture methods for their P uptake efficiency. In flow cultures, P was maintained at 0.25, 2.5, and 25 μ moles; while in spoil cultures P was added at 0, 25, and 75 μ g/g spoil to a P-deficient spoil. Alfalfa, birdsfoot trefoil, and emerald crownvetch showed P deficiency symptoms, while burning bush and Russian thistle showed no such deficiency symptoms; their dry matter yields in the 0.25- μ m P treatment was 24% and 36%, respectively, of their maximum yields obtained with 25 μ M P. The root dry weight ratio in the legumes increased from an average 0.22 to 0.43 with the increase in solution P, while in the weeds the increase was 0.14 to 0.30.

The low susceptibility of Russian thistle to P deficiency was also demonstrated in the spoil culture experiment. Higher P concentrations were observed in weeds than in legumes or grasses. In general, increases in P supply increased P concentrations and decreased Zn concentrations. The influence of P fertilization on the tissue concentrations of Mn and Zn was similar in both flow culture and spoil culture methods. Research done under contract J0295015 by the University of North Dakota. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-171439; paper copy price code A03.

OFR 47(13)-83. Ecological Studies on the Revegetation Process of Surface Coal Mined Areas in North Dakota. 13. Statistical Analysis, by Richard H. Bares. June 1982. 18 pp. This paper describes the purpose and application of 17 statistical and mathematical procedures used in this 13-volume report. The objective of the report is to help readers to better understand the purpose and utility of statistical techniques applied to data from the various subprojects reported in this series. Research done under contract J0295015 by the University of North Dakota. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-171447; paper copy price code A02.

OFR 48-83. System To Prevent Clogging of Gas Sampling Tubes, by Kyle W. Charlton and Lloyd D. Bowman. Dec. 18, 1981. 91 pp. 39 figs. The Bureau of Mines utilizes special testing methods for the analysis of underground mine atmospheres for use during or after mine disasters and fires. These methods depend upon drawing sample gas to the surface through multiple tube bundles with the subsequent analysis of grab samples or the automatic analysis by often remotely located instruments on a continuous, 24-hour basis. During cold weather, low ambient temperature causes condensation and freezing of condensable vapors in the sample, which can result in delayed response times or complete blockage of the sample line. This report covers research and resulting development conducted by the Bureau to produce a reliable method to selectively remove condensable vapors and particulate in the sample gas stream under worst-case field conditions. The effort resulted in two prototype systems that have greater field utility than originally anticipated. Research done under contract H0308042 by Charlton Technology Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; U.S. Department of Energy facilities in Pittsburgh, PA, and Morgantown, WV; Mine Safety and Health Administration facilities in Aliquippa and Pittsburgh, PA, and Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Wash-

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ington, DC. Order ONLY from NTIS: PB 83-178806; paper copy price code A05.

OFR 49-83. State-of-the-Art Environmental Assessment of Onshore Disposal of Manganese Nodule Rejects, by F. A. Kennedy, E. O. Porter, J. L. Deis, F. C. Brown, and R. E. Versaw. July 30, 1982. 238 pp. 43 figs. As part of a cooperative research program with the National Oceanic Atmospheric Administration, the Environmental Protection Agency, and the U.S. Fish and Wildlife Service, the Bureau of Mines contracted for an environmental assessment on onshore waste disposal that is expected to occur with the development of commercial deep seabed mining. The assessment was conducted in order that testing and refinement of nodule waste disposal techniques can be completed prior to 1988, when commercial seabed mining can begin under U.S. legislation. Three classes of process and four classes of waste disposal techniques were identified, and five sites were selected as representative of first-generation nodule operations. Each site-process-disposal technique combination was compared against potential effects to determine important characteristics of the rejects and the sites. Regulatory requirements were also considered at each site to identify important issues and their effect on the permitting process. The principal conclusions are (1) uncertainties in the regulatory regimes for hydrometallurgical process tailings, primarily regarding classification as hazardous wastes; (2) slags from nodule processing that are expected to be inert and relatively easy to dispose of at all sites; and (3) additional physical and chemical information on properties of rejects from all processes that will be necessary to predict environmental effects. Research done under contract J0100085 by Rogers, Golder & Halpern, EIC Laboratories, and Golder Associates. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-175380; paper copy price code A12.

OFR 50-83. Demonstration of Noise Control Techniques for the Crushing and Screening of Nonmetallic Minerals, by Robert J. Pokora and Terry L. Muldoon. December 1981. 187 pp. 64 figs. The objectives of this program were to identify the prevalent sources of crushing and screening noise in portable and stationary plants, design retrofit noise control treatments for those sources, and field test control treatments under actual operating conditions. A survey was made to assess the variety of noise sources, to determine the worker exposure to those sources, and to identify possible constraints that should be considered in designing and installing retrofit controls. Retrofit noise control treatments designed included a primary crusher operator control booth; screen decks made of resilient cloth; screen feedbox impact pads; and rubber feed plates and chute lines, and noise attenuating curtains for a secondary crusher. A new primary crusher control booth was installed at one plant and the noise levels were reduced from 97 dBA to 78 dBA. Screen noise at two secondary crushing plants was reduced by 3 dBA, and crusher noise at one of these plants was reduced by 5 dBA. Noise levels at normal outside operator and cleanup locations were not significantly reduced in the second plant because of rapid wear of installed materials, but at the other plant the retrofit noise control materials displayed excellent

wear characteristics. Research done under contract J0100038 by Foster-Miller, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-173039; paper copy price code A09.

OFR 51-83. Telephone Communication System for a Deep-Vein Metal Mine, by Terry S. Cory. March 1982. 108 pp. 17 figs. This report describes the results of a program to design, procure, install, and evaluate a multichannel underground telephone system of modern design in the Sunshine Silver Mine near Wallace, ID. The report contains a cost benefit analysis for such a system using estimates of operational data for the Sunshine Mine. The results show a centrally switched telephone system of conventional design with ruggedized phone enclosures and special environmentally sealed dial pads to be the most economical. Research done under contract J0100093. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-173021; paper copy price code A06.

OFR 52-83. Microseismic Applications for Mining—A Practical Guide, by Wilson Blake. July 12, 1982. 208 pp. 82 figs. Microseismic activity and properties of microseismic events are treated so that these parameters can be taken into account when developing monitoring equipment. Microseismic equipment is discussed to provide familiarization with the components of monitoring systems. Factors to be considered and procedures for developing a microseismic monitoring system are presented. Both physical and electrical considerations for the installation of a monitoring system are discussed in detail. The operation of a microseismic system including data analysis procedures is presented. Field examples to illustrate use of microseismic data in evaluating ground control problems in a number of case histories are also included. Research done under contract J0215002. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; U.S. Department of Energy facilities in Denver, CO, and Pittsburgh, PA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-180877; paper copy price code A10.

OFR 53-83. Investigation of Extinguishing Agents for Coal Dust Explosion, by Marcel Vanpee and Reginald W. Tyler. November 1982. 83 pp. 35 figs. Eight extinguishing powders were tested in five types

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of diffusion flames. The effect of flame temperature on the inhibition efficiency was investigated by varying the oxygen index of the flame-supporting atmosphere. In addition, a spectrographic investigation of powder-flame dissociation products was carried out on the methane-air-ABC ($\text{NH}_4\text{H}_2\text{PO}_4$) flame. Dissociation products for this flame included PO, PH, NH, and Na. It was concluded that the main factor to be considered in the efficiency of the powder is the flame temperature. Purple K (KHCO_3) was typically inefficient in low-temperature flames and very efficient in high-temperature flames. On the other hand, ABC ($\text{NH}_4\text{H}_2\text{PO}_4$) was found to lose its efficiency at high temperatures but to be quite efficient in the low-temperature flames. The effect of temperature is offered as an explanation of the poor efficiency of KHCO_3 against coal dust explosions in contrast to the high efficiency of the phosphate salts against coal dust explosions. Research done under contract J0395097 by the University of Massachusetts. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; U.S. Department of Energy, Pittsburgh, PA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-180885; paper copy price code A05.

OFR 54(1)-83. Constitutive Relations of Coal and Coal Measure Rocks. Volume I. Interrelationship of Mechanical, Index and Geologic Properties of Coal Measure Rocks, by T. G. Barbour, R. H. Atkinson, and Hon-Yim Ko. March 1980. 111 pp. 9 figs. Cores of coal measure rocks from five mines across the United States were tested for mechanical, index, and mineralogic properties. About 600 samples were tested to determine 15 mechanical property parameters, 7 index parameters, and 30 geologic parameters. The results were analyzed for their statistical distributions, and bivariate and multivariate, linear and nonlinear correlations were attempted for these groups. Significant correlations were found for some of the parameters. On the basis of these statistics, predictive models are postulated for the mechanical properties on the basis of index and geologic parameters. Research done under grant G0155056 by the University of Colorado. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; U.S. Department of Energy, Pittsburgh, PA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-178244; paper copy price code A06.

OFR 54(2)-83. Constitutive Relations of Coal and Coal Measure Rocks. Volume II. A Study of the Orthotropy of Coal and Other Rock Materials, by D. J. Hawk and Hon-Yim Ko. March 1980. 129 pp. 13 figs. The mechanical properties of coal are often represented by the orthotropic material model, which consists of nine elastic constants. The material symmetries involved are found in coal primarily because of the natural process by which the coal

was formed. In this report, the material properties of five U.S. coals, as obtained from cubical testing, are examined using the assumption of the orthotropic material model as a basis for comparison. An analysis is performed on each set of coal material data in order to examine its conformability to other, less complex material models—the transversely isotropic model consisting of five elastic constants and the isotropic model consisting of two elastic constants. In addition, the material properties of the two U.S. shales are analyzed, based on the assumption that they comply with the transversely isotropic model. An analysis similar to that performed on the coal material is applied to the shale to determine the conformity of its material properties to the isotropic model. Research done under grant G0155056 by the University of Colorado. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; U.S. Department of Energy, Pittsburgh, PA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-178251; paper copy price code A07.

OFR 54(3)-83. Constitutive Relations of Coal and Coal Measure Rocks. Volume III. Drying Shrinkage and Creep Behavior of Coal, by R. J. Tocher and Hon-Yim Ko. March 1980. 114 pp. 35 figs. Uniaxial testing was performed on coal specimens to determine the time-dependent response. The testing was carried out on coal from six mine sites throughout the Western United States and Pennsylvania. Testing configurations were varied to allow analysis of moisture dependency, stress level, and specimen orientation. Several theories were presented for the behavior of coal due to moisture diffusion. Experimental results showed the correlation between the theories and the actual material response. Coal deformation was found to be highly dependent on the moisture level of the testing environment. Moisture migration causes drying and shrinkage which lead to progressive degradation of the material. The coal tested experienced a rebound if saturated after a period of drying. This type of time-dependent behavior overshadows a noticeable creep behavior. Analysis of one series of creep test results was performed. A relationship was developed on the basis of a simplified rheological model to describe the coal response to uniaxial stress. Previous empirical formulations in the form of power laws were compared and their deficiencies pointed out. Research done under grant G0155056 by the University of Colorado. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; U.S. Department of Energy, Pittsburgh, PA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-178269; paper copy price code A06.

OFR 55-83. Automated Blast Hole Logging and Design, by D. E. Scheck, L. H. Mitchell, and G. W. Mack. December 1982. 126 pp. 29 figs. A blast hole drill was instrumented and equipped with a digital recorder to monitor quantitative drilling

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parameters such as down pressure and rotational speed of the bit. This information was captured on nonvolatile memory and transmitted to a main-frame computer for analysis. The variation in the energy required to turn the bit was found to be correlated with the geological structure of the overburden. This information was used to design explosive loads with hole size, pattern, and powder factor held constant. The decked shots designed from the drilling parameters produced better fragmentation than the mine's standard undecked design. The monitor system on board the blast hole drill was modified to perform the data analysis, identify the hard to fragment zones, and print the recommended blast designs. The final task was to design and build a hardened version of the system. This equipment is now used routinely and is available for further research and testing. Research done under grants G1105006 and G1115006 by Ohio University. Available for reference at the Office of the Assistant Director—Mining Research, Bureau of Mines, Washington, DC; Bureau of Mines, Pittsburgh, PA; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 56-83. An Investigation of the Effects of Explosive Primer Location on Rock Fragmentation and Ground Vibrations.

by Norman S. Smith. 1982. 10 pp. 5 figs. The degree of fragmentation and the magnitude of ground vibration from rock blasting are affected by numerous factors. Previous investigations have studied many of these factors; however, the influence of the blasthole primer location in a bench blast on the resulting degree of fragmentation or peak particle velocity of ground vibrations has not been investigated. This investigation used a series of three-hole, reduced-scale bench blasts in a dolomite rock mass to examine and compare effects of collar and bottom priming, the two most commonly used primer locations, on fragmentation and near-field ground vibrations. It was found that collar priming produced trends of a lower degree of fragmentation and of greater peak particle velocities than did bottom priming. There was no significant variance in toe formation or overbreak due to primer location. Research done under grant G1114028 by the University of Missouri—Rolla. Available for reference at the Office of the Assistant Director—Mining Research, Bureau of Mines, Washington, DC; Bureau of Mines facilities in Avondale, MD, and Pittsburgh, PA; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 57-83. Evaluation of Effectiveness of Fly Ash in Fixing Metals Within and Controlling Leachate Contamination From Tailings Ponds,

by John L. Sonderegger and Joseph J. Donovan. December 1982. 42 pp. 15 figs. Western, calcium-rich fly ash was used as a tailings amendment in laboratory studies with pyrite, galena, and tailings from a complex sulfide deposit. The base buffering capacity of the fly ash reduced dissolved heavy metal content up to three orders of magnitude. When used in this manner, with a 10 wt-pct fly ash amendment per unit weight of pyrite in the tailings, at least a three order of magnitude reduction in quantity of heavy metals leached through the tailings and into local ground and surface water systems can be expected. Research done under grants G1105005 and G1115005 by the Montana College of Mineral Science and

Technology. Available for reference at the Office of the Assistant Director—Mining Research and the Office of Minerals and Materials Research, Bureau of Mines, Washington, DC; Bureau of Mines facilities in Avondale, MD, and Salt Lake City, UT; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 58(1)-83. Development of Selective Submicrometer Particulate Fire Detectors for Underground Metal Mines. Volume I,

by G. F. Skala and F. W. VanLuik, Jr. December 1979. 129 pp. 43 figs. The development of two prototype instruments for the discrete detection of submicrometer particles in metal and nonmetal mines is described. The detectors are designed to utilize properties of submicrometer particles to distinguish between those produced by fires from mine ambient particles primarily resulting from diesel engine exhaust. One detector is based on the electrical tagging of the diesel exhaust particles with subsequent detection of uncharged fire particles utilizing an ion chamber as the primary sensor preceded by an electrostatic precipitator. The other detector is based on the ability to pyrolyze fire-produced particles, but not diesel exhaust-produced particles, into a high concentration of smaller particles. This concentration was compared with the concentration of unpyrolyzed fire particles and caused an alarm on a preset value. The primary sensors used were two matched cloud chamber devices. Each detector demonstrated good ability to discriminate between fire and ambient diesel-produced particles. The report contains a literature survey, experimental charging and pyrolysis data, detector design descriptions, and test results. Research done under contract H0387025 by Environment/One Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; U.S. Department of Energy, Pittsburgh, PA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-178947; paper copy price code A07.

OFR 58(2)-83. Development of Selective Submicrometer Particulate Fire Detectors for Underground Metal Mines—In-Mine Evaluation. Volume II,

by G. F. Skala. January 1982. 36 pp. 10 figs. Testing of two prototype instruments for the discrete detection of submicrometer particles in metal and nonmetal underground mines is described. The detectors are designed to utilize properties of submicrometer particles to distinguish between those produced by fires from mine ambient particles primarily resulting from diesel engine exhaust. One detector is based on the ability to pyrolyze fire-produced particles, but not diesel exhaust particles. An alarm is produced when the ratio of pyrolyzed to unpyrolyzed particles exceeds a present value. The other detector utilizes a continuous-flow ion chamber preceded by a denuder to remove charged particles. Discrimination against diesel-produced submicrometer particles results because the diesel particles are naturally more highly charged than fire-produced particles. In-mine testing was conducted over a period of several months. Both detectors exhibited an ability to discriminate against diesel

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exhaust. However, problems with the recording equipment, and with the detectors themselves due to large ambient dust particles, prevented enough data from being obtained to choose between the two methods. Research done under contract H0387025 by Environment/One Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; U.S. Department of Energy, Pittsburgh, PA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-178954; paper copy price code A03.

OFR 59-83. Reconnaissance of Tin and Tungsten in Heavy Mineral Panned Concentrates Along the Trans-Alaska Pipeline Corridor, North of Livengood, Interior Alaska, by James C. Barker. 1983. 24 pp. 3 figs. In 1978 through 1980, the Bureau of Mines collected a series of 514 panned concentrates from selected granitic regions along a section of the Trans-Alaska pipeline corridor, bounded on the south by Livengood and on the north by the Koyukuk River. The methods of sample collection and analytical procedures are described. Sample analyses for tin, as well as for tungsten and eight other common pathfinder elements, are presented. The data indicate both tin and tungsten anomalies in the vicinity of the northern Ray Mountains to the Sithylenkat Lake area, near the Fort Hamlin Hills, and west of Caribou Mountain. Only tungsten anomalies occur on upper Bonanza Creek. Research done by the Alaska Field Operations Center. Available for reference at Bureau of Mines facilities in Anchorage, Fairbanks, and Juneau, AK; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 60-83. Improved Ground Control Safety in the Stone, Sand and Gravel Industries, by Tuncel M. Yegulalp and S. H. Boshkov. June 10, 1981. 299 pp. 8 figs. The objective of this study was to categorize mining operations in the stone and sand and gravel industries into areas of similar ground control functions and define initial factors affecting operational safety in each area by utilizing publicly available data, telephone interviews, and onsite observations. The findings and recommendations presented in this report are based on information collected during the two phases of the project. The report also contains, in part, the collective qualitative opinion of the operators with respect to Government rules and regulations on ground control safety and the implementation of these rules and regulations by Government inspectors. Research done under contract J0100027 by H. H. Aerospace Design Co., Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-183111; paper copy price code A13.

OFR 61-83. Design, Construction & Development of In Situ Mining Wells, by David L. Shuck and

James N. Brooke. November 1982. 135 pp. 35 figs. This report describes the current methods of design, construction, and development of wells for in situ leaching of uranium. The discussion includes the alternatives for well design drilling equipment and fluids, grout formulation and emplacement, well integrity testing and repair, and well development and stimulation. Current practice in these areas was determined through interviews and discussions with eight operators of commercial-scale in situ facilities. Based on this information and previous experience, recommendations are made regarding well design, construction, and development for in situ leaching. Research done under contract J0218018 by High Life Helicopters, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-183418; paper copy price code A07.

OFR 62-83. Utilization of Nickel Refining By-Products on Agricultural Lands, by V. V. Volk, E. H. Gardner, P. J. Sheets, and R. J. Gulack. Mar. 1, 1982. 89 pp. 6 figs. Laboratory, greenhouse, and field experiments were conducted to determine the effects of a tailings material and a magnesium ammonium phosphate (MgAP), produced from a Ni refining operation, on plant growth and soil properties. The tailings contain high levels of soluble salts (9.7 mmhos/cm), $\text{NH}_4\text{-N}$ (0.1%), total Ni (2,470 $\mu\text{g/g}$), Cr (3,825 $\mu\text{g/g}$), and Co (313 $\mu\text{g/g}$), and low levels of Ca (1.3 meq/100 g) and extractable P (1.0 $\mu\text{g/g}$). Tall fescue (*Festuca arundinacea* S.) was grown on soils amended with tailings and plant yield and elemental composition was determined. The MgAP was compared with $\text{MgNH}_4\text{-PO}_4$ (MgKAP) and traditional fertilizer as sources of N and P for tall fescue and white clover. Tall fescue established slowly on soils amended with the highest rate of tailings while other plants grew well. Concentrations of Mn, Ni, Cr, and Co in tall fescue grown on the treated soils were within normal ranges. The tailings should be leached further to reduce the $(\text{NH}_4)_2\text{SO}_4$ content to allow better stand establishment at high tailing application rates. All fertilizer materials provided similar levels of N and P, as evidenced by plant yield and elemental content. Research done under contract J0295058 by the Oregon Agricultural Experiment Station. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mining Safety and Health Administration, Arlington, VA; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-183129; paper copy price code A05.

OFR 63-83. Mesabi Range Water and Iron Ore Industry, by Anching Line. October 1981. 269 pp. 17 figs. The purpose of this study was to provide an evaluation of the current state-of-the-art information concerning the availability, need, use, and degradation of the water systems associated with Mesabi Range iron ore mining. The study was carried out in three phases: (1) characterization of the Minnesota iron ore industry and associated water systems on a regional basis, (2) detailed individual case analysis of present and future iron ore developments and the associated

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watershed systems, and (3) impacts of potential copper-nickel development on the watershed requirements of the iron ore industry. The conclusions are presented in a summary preceding the three phases of the report. Research done under contract J0208023 by the Uintex Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 64-83. Alumina Miniplant Operations—Removal of Iron From Aluminum Nitrate Pregnant Liquor by Solvent Extraction, by Roy T. Sorensen. 1982. 19 pp. 5 figs. The Bureau of Mines investigated the recovery of aluminum by nitric acid leaching of calcined kaolinitic clay. Most iron impurities were leached from the calcined kaolin during the extraction of aluminum and must be removed before or during the crystallization of aluminum nitrate nonahydrate in order that the subsequent thermal decomposition step will yield an alumina product of acceptable iron analysis. Solvent extraction miniplant studies using di(2-ethylhexyl) phosphoric acid in kerosene diluent have demonstrated that iron content in aluminum nitrate pregnant liquors can be decreased to levels of less than 0.0007 pct (7 ppm), expressed as Fe_2O_3 . A number of the miniplant tests were interrupted or terminated because of an increase in the viscosity of the solvent extraction circuit flowstreams. Under these conditions circuit control was difficult, high alumina loss occurred, and iron impurities increased in the recycled solvent. An addition of less than 0.5 mol of nitric acid per liter increased the free acid content of the pregnant liquor and eliminated the viscosity problem in solvent extraction. Bench-scale research was not confirmed because most miniplant testing was not at best operating parameters. Research done by the Boulder City Engineering Laboratory. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Avondale, MD, Twin Cities, MN, Rolla, MO, Boulder City and Reno, NV, Albany, OR, Pittsburgh, PA, and Salt Lake City, UT; Office of Assistant Director—Minerals and Materials Research, Bureau of Mines, Washington, DC; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 65(1)-83. Reduction of Land Recontouring Costs. Volume I—Texas Lignite Field, by J. W. Howland and Lee Wray Russell. September 1981. 39 pp. 8 figs. To determine their effectiveness in different climate and soil conditions, a demonstration of dozer blades specifically designed for recontouring mine spoil was conducted at an east Texas surface coal mine. The specialized equipment included a 48-ft angle blade, a modified 24-ft "U" blade, a 13-ft-deep "U" blade, and a 24-ft grading bar. Both the 48- and 24-ft "U" blades were mounted in a two-tractor, single-operator configuration. To meet flotation problems common in this mining region, a 22-ft lightweight blade was developed and demonstrated for use on a 400- to 430-hp tractor. The demonstration involved 1,185 acres and showed a 50% reduction in reclamation costs and a 47% reduction in fuel requirements over conventional equipment. Research done under contract H0282035 by Russell & Sons Construction Co., Inc. Available

for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS. PB 83-191569; paper copy price code A03.

OFR 65(2)-83. Reduction of Land Recontouring Costs. Volume II—Bituminous Coal Field, Northeast Arizona, by J. W. Howland and Lee Wray Russell. June 1982. 48 pp. 9 figs. A demonstration of dozer blades was conducted at a northeast Arizona surface coal mine to determine their effectiveness in different climate and soil conditions. The specialized tools were a 48-ft angle blade on a side-by-side tractor, a 24-ft grading bar, a modified 24-ft "U" blade on a side-by-side tractor, and a 13-ft-deep "U" blade. Interest in the increased dirt-filling capacity of a previously built 22-ft blade resulted in the design of a new center-flow blade of good versatility able to maintain increased flow in otherwise difficult-to-move spoil. The demonstration involved 263 acres and showed a reduction of 50% in reclamation costs and 20% in fuel requirements over conventional equipment. Research done under contract H0282035 by Russell & Sons Construction Co., Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-191577; paper copy price code A03.

OFR 66-83. Frictional Ignition Suppression by the Use of Cutter-Drum Mounted Sprays, by R. O. Agbede, K. L. Whitehead, R. L. Mundell, and R. D. Saltsman. January 1982. 135 pp. 46 figs. The objective of this investigation was to conduct tests with a full-scale longwall shearer drum in a simulated mine environment to determine the effectiveness of drum-mounted water sprays in controlling frictional ignitions. The tests were conducted with a drum equipped with a single bit that cuts a sandstone block enclosed in a chamber filled with a combustible methane-air mixture. Without the sprays operating, no ignition occurred when only the carbide tip was impacting the stone. The likelihood of ignition increased with degree of bit wear and exposed steel contact area. Backflushing sprays, properly applied, were effective in controlling ignitions, but pickflushing and bit-cooling sprays were ineffective. Decreasing drum speed did not reduce the likelihood of ignitions until a bit peripheral speed of 200 fpm, 14 rpm for a 54-in drum, was reached. Research done under contract J0395040 by Bituminous Coal Research, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-191593; paper copy price code A07.

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OFR 67-83. Coal Dust Combustion in a Stirred Reactor: Evaluation of Combustion and Extinction Mechanics in Coal Dust Explosion Flames, by R. H. Essenhigh. October 1981. 78 pp. 20 figs. The relative effects of seven additives (N_2 , He, CO_2 , fly ash, $KHCO_3$, NaCl, and $NH_4H_2PO_4$) on extinction limits of coal dust flames have been studied in a 200-cm³ jet-stirred reactor. Conditions in the reactor are known to be comparable to those at the head of a coal dust explosion flame. $KHCO_3$, NaCl, and $NH_4H_2PO_4$ are commercial fire retardants and are presumed to be chemically active; but test results support the presumption only for NaCl and $NH_4H_2PO_4$. Curves of weight-of-additive to suppress the flame and temperature at extinction were obtained as a function of stoichiometry. For all but the NaCl and $NH_4H_2PO_4$, 20% to 30% additive in the mixture of coal plus air plus additive is required for extinction of maximum combustibility. With NaCl and $NH_4H_2PO_4$, the figures were 13% and 4%, respectively. The extinction mechanism is presumed to be chain termination of volatiles combustion. Extinction temperatures were found to be substantially independent of kind of additive, with essentially constant values in the fuel-rich region, and declining as fuel concentration decreased. Research done under contract J0199018 by the Ohio State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; U.S. Department of Energy, Pittsburgh, PA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-191585; paper copy price code A04.

OFR 68-83. Preliminary Predictive Model of Subsidence Process Over Room and Pillar Workings. Phase I: Definition of Factors, by S. K. Mathur and M. R. Mikkilineni. April 1982. 113 pp. 38 figs. The report identifies all the possible activities, variables, and factors that contribute to the surface subsidence process over room-and-pillar workings. These factors are responsible for mine instability and collapse that ultimately transforms into surface subsidence. Such a failure mechanism is initiated by the failure of the mine floor bed and/or the failure of the pillars or the failure of the roof after second mining, which eventually brings down the roof. The individual responses of the pillar, floor, and roof rocks to the mining-induced stresses and the complex interaction between these components cannot be attributable to any single factor. Also, no attempt has been made to quantify the significance of each of these factors and relate to the ground subsidence due to the lack of field data. The discussion here is centered primarily on the first mining, although second mining is mentioned very briefly. Research done under contract J0100073 by MRM Engineers. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; U.S. Department of Energy, Pittsburgh, PA; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-191759; paper copy price code A06.

OFR 69-83. Geophysical Hazard Detection From the Working Face, by Sidney A. Suhler, Thomas E.

Owen, Bob M. Duff, and Ron J. Spiegel. Jan. 15, 1981. 234 pp. 80 figs. The objective of this project was to define and demonstrate the feasibility of remotely sensing abandoned mine workings from underground. Geophysical probing techniques based upon electrical, seismic, and electromagnetic methods were evaluated; the seismic method was determined to be the most favorable. Guided seismic wave propagation in coal seams offered the potential of detecting inundation hazards 200 ft or more ahead of mining. Controlled waveform seismic source transducers and specialized receiving transducers were developed with emphasis on concept demonstration and experimental guided wave propagation studies. Two major field tests were undertaken in Kentucky and Virginia. Guided wave propagation phenomena were observed in 54- and 70-in coal seams. Normal mode Love waves and Rayleigh-type guided waves were generated by the controlled-source transducers and by hammer blows on a steel anvil attached to the coal. Numerical evaluations of theoretical velocity dispersion characteristics of both Love and Rayleigh-type waves were confirmed in the experimental test results. Analyses of the test results and recommendations for additional future research efforts are presented in detail. Research done under contract H0272027 by the Southwest Research Institute. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-191742; paper copy price code A12.

OFR 70-83. Video Image Sensor Systems Applied to Pit Slope Displacement Monitoring, by Robert J. Dompe, James L. Eirls, Rodney D. Smith, William G. McKinley, and Gordon B. Hall. December 1982. 274 pp. 92 figs. The objective of this program was to develop a cost-effective microprocessor-based electronic image sensor for monitoring pit slope displacement to detect and/or predict impending slope failure in surface mines. A background study and data analysis yielded a performance specification for candidate video slope monitoring systems. A design concept was developed based on using a pair of solid-state video cameras located on precision pointing assemblies. The digital images from the cameras are compared and, using electronic triangulation, slope topology is calculated. The current and past locations of operator-selected features are compared to determine pit slope displacement. A proof-of-concept test was performed using a laboratory model of a pit slope. Based on the successful results of that test, it is recommended that an in-mine evaluation be performed using a full-scale prototype video slope monitoring system. Research done under contract J0295040 by Tracor MBA and Science Applications. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-191734; paper copy price code A13.

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OFR 71-83. Zinc Retorting Without Pollution, by George W. Healy. Nov. 30, 1982. 53 pp. 16 figs.

The direct retorting of zinc sulfide concentrates in the presence of lime and carbon was examined on a laboratory scale in an apparatus that permitted the volatilized zinc to be condensed and weighed while the reaction gases were analyzed periodically with a gas chromatograph. The zinc vapor was calibrated on prepared gas mixtures of CO and COS and of CO₂ and SO₂ in nitrogen. Neither of these sulfur gases were detected. Increasing the proportion of lime and carbon enhanced zinc recovery, as did higher temperature; going from 90% to 110% of theoretical reagents and from 1,100° to 1,200° C increased recovery of zinc from 75% to 93%. The reaction rate for direct retorting was compared with that for reduction of oxide with carbon using theoretical amounts of reagents. It was found that above 600° C, where carbon gases were first detected, reaction proceeded almost twice as fast for oxide plus carbon as for sulfide plus lime and carbon. Since CaS might react with the atmosphere to give off sulfur gases, it was attempted to stabilize it by oxidizing to CaSO₄. Because a residue of ZnS remained in the material from incomplete retorting, SO₂ was evolved while the CaS oxidized. Oxidation was 20% complete at 800° C, rising to 90% at 1,200° C. It was concluded that while the retorting step is nonpolluting, if stabilization of CaS is included in the process, the pollution is a problem. Research done under contract J0295069 by the University of Utah. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-191726; paper copy price code A04.

OFR 72-83. Monitoring of Gases From Explosives Detonated in an Underground Mine, by Meliton M. Garcia, Edward P. Jucevic, and W. Cary Kittrell. June 30, 1982. 81 pp. 18 figs.

The concentration of six different gases produced by the detonation of four explosives was measured in a dry underground metal mine during actual mining operations. The four explosives included one semigelatin dynamite, one gelatin dynamite, and two water gel explosives. A standard drill pattern was used to detonate the explosives as a full-face round in the drift. The gases released by the explosion were trapped in the drift. The concentration of the gases in the test chamber were measured by direct read-out instruments. The average volume of each gas per pound of explosives detonated in the following ranges, in cubic feet per pound: NO, 0.04 to 0.14; NO₂, 0.03 to 0.10; CO, 0.08 to 0.45; SO₂, 0.001 to 0.006; NH₃, 0.003 to 0.027; and CO₂, 1.82 to 7.02. Research done under contract H0395098 by the University of Arizona. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Rolla, MO, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-191718; paper copy price code A05.

OFR 73-83. Earth Resistivity Investigations in Reclaimed Surface Lignite Mine Spoils, by A. E. Kehew and G. H. Groenewold. November 1982. 98 pp. 65 figs. Earth resistivity surveys using the Wenner elec-

trode configuration were made in unmined areas and reclaimed spoils at three surface lignite mines in western North Dakota. Automatic interpretation of the curves was accomplished with the method of Zohdy and Bisdorf. Overburden materials become more homogeneous with respect to resistivity during the mining and reclamation process. The spoils curves show localized heterogeneities probably related to discontinuous moisture content variations in the spoils. Consistent resistivity differences in spoils occur between mines with overburdens of different mineralogic compositions. Ground water chemical compositions in terms of total dissolved solids (TDS) is inversely correlated with apparent resistivity at the 80-ft spacing from a survey centered at a piezometer screened near the base of the spoils. Better inverse correlation is probably prevented by high variability in TDS within the spoils ground water. A useful predictive relationship may be the plot of mean apparent resistivity at the 80-ft spacing for an entire mine against mean TDS for all wells in spoils at that mine. Research done under contract J0275010 by the North Dakota Geological Survey. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 74-83. Downhole Rock Borehole Shear Tester, by R. L. Handy, Bruce Roorda, and Steve Futrell.

May 30, 1982. 22 pp. 10 figs. The goal of this research was to adapt the rock borehole shear test for use in deep, small-diameter boreholes. Operating somewhat on the principle of a rock bolt, the borehole shear test measures both the expansion pressure and pulling force to give discrete measures of rock shearing strength as a function of the applied normal pressure. A new instrument was designed and built to fit into a 2-3/8-in-diam hole. Complications attributed to constraints of the small hole, the added requirements of an in-hole anchor to push against, and a rotating shear plate cleaner for repeated tests downhole made the design unreliable. One reason for the complexity could be the length, which is over 10 feet. The instrument also employs concentric cylinders and one hydraulic cylinder bored into the piston of another, or it would be even longer. Since advanced drilling technology has greatly reduced costs of drilling 5- or 6-in-diam holes, the downhole tester should be redesigned and simplified for use in a larger diameter drill hole. Research done under grant G0284002 by the Iowa State University, Ames. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 75-83. A Study of Stability Problems and Hazard Evaluation of the Kansas Portion of the Tri-State

Mining Area, by J. R. McCauley, L. L. Brady, and F. W. Wilson. January 1983. 193 pp. 46 figs. The Kansas portion of the tristate (southwestern Missouri, southeastern Kansas, and north-

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eastern Oklahoma) lead and zinc district was studied in order to compile maps and report on the location and extent of past mining activities and the resulting hazardous surface effects of mining. Information was acquired from old mine maps, reports, personal interviews, aerial photo interpretation, and fieldwork. Three maps have been prepared that show (1) extent of underground workings and mine shafts, (2) hazardous mine openings including open mine shafts and mine collapses and (3) waste piles and tailings ponds. In addition, tabulations are included for all mine hazards as well as large waste piles and hazardous tailings ponds. Research done under contract J0100131 by the Kansas Geological Survey. Available for reference at Bureau of Mines facilities in Denver, CO, Rolla, MO, and Pittsburgh, PA; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 76-83. A Study of Stability Problems and Hazard Evaluation of the Oklahoma Portion of the Tri-State Mining Area, by Kenneth V. Luza. February 1983.

147 pp. 20 figs. Approximately 2,240 acres are underlain by underground lead and zinc mines in northeastern Oklahoma and approximately 2,900 acres are overlain by mine and mill waste materials. The principal objectives of this investigation are to (1) compile on a series of maps the location and extent of past mining activities and the resulting surface effects, (2) identify hazardous areas with potential for future damage to persons or property, and (3) consider methods for providing public protection from existing and potentially hazardous conditions. Research done under contract J0100133 by the Oklahoma Geological Survey. Available for reference at Bureau of Mines facilities in Denver, CO, Rolla, MO, and Pittsburgh, PA; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 77-83. Fire Hazard Evaluations of Mine Materials in a Small-Scale Combustibility Apparatus, by A. Tewardson. June 1982. 79 pp. 8 figs. Fourteen commonly used mine materials were evaluated for combustibility in a small-scale apparatus. The data obtained and predictions of these data from large-scale fires were successfully validated for conveyor belting, brattice cloth, and treated and untreated wood. All the wood treatments except Fireguard were found to be effective for reducing the fire hazard. Five parameters proposed for rating mine materials are (1) ignition and flame spread, (2) generation of combustible vapors, (3) generation of heat, (4) generation of toxic and corrosive products, and (5) light obscuration by smoke particulates. Research done under contract J0395125 by Factory Mutual Research Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-196204; paper copy price code A05.

OFR 78-83. Study of Automated Continuous Explosive Excavation Systems, by E. Concha and J. A.

Bartol. January 1982. 95 pp. 27 figs. The concept of an automated continuous explosive excavation system (ACEE) for the underground mining applications of development drifting and room-and-pillar mining has been evaluated in comparison with conventional drill, blast, and muck operations. The role and possible extent of application of this method was examined in a defined mine environment. Step-by-step procedures were developed to quantify the evaluation process where this appeared feasible. One conclusion was that a system approach to ACEE design is not only feasible but attainable within the state of the art. Several preliminary design concepts were formulated and examined in order to determine what further research or development might be needed to realize them. Research done under contract J0100082 by Applied Engineering Resources, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-196212; paper copy price code A05.

OFR 79-83. Remote Monitoring of a Coal Waste Impoundment in West Virginia, by Gordon E. Green and David A. Roberts. February 1982. 175 pp. 70 figs. This report addresses remote monitoring of coal waste impoundments for stability. Existing automated geotechnical monitoring systems are described and reviewed along with details of instruments suitable for such systems. An impoundment in West Virginia, which was in the construction stage, was instrumented and monitored between July 1979 and May 1981. Sensors that measure surface and subsurface parameters including settlement, horizontal deflection, surface tilt, pore water pressure, seepage, pond level, and meteorological parameters were installed. Data from 37 sensors were collected by on-site logger and transmitted by telephone to a central processing station in Seattle for recording and interpretation. Difficulties were encountered with telephone and powerline outages and malfunction of electronic units. Detailed descriptions of the design and performance of the system are provided along with evaluation and comparison with other systems. Recommendations for improving and expanding the capabilities of the monitoring system are given. Research done under contract H0282041 by Shannon & Wilson, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-196584; paper price code A08.

OFR 80-83. Geological Sampling and Magnetic Surveys of a Tungsten Occurrence, Bonanza Creek Area, Hodzana Highlands, Alaska, by Karen H. Clautice. Mar. 29, 1983. 80 pp. 23 figs. The tungsten occurrence at the margin of the Kanuti batholith in the Bonanza Creek area was investigated by the Bureau of Mines for the Bureau of Land Management as part of an inventory of mineral deposits within and bordering the trans-Alaska oil pipeline corridor. Fieldwork was conducted over a period of 6 weeks

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during the summer of 1979. Analyses and sample location maps were compiled from stream sediment, panned concentrate, soil, and rock samples. Analytical methods included atomic absorption, X-ray fluorescence, emission spectrography, and neutron activation. Tungsten and molybdenum, occurring in the minerals scheelite and molybdenite, were found in trace amounts throughout the 30-mi² project area. The highest grade tungsten mineralization was found in a pyrrhotite-rich chalcopyrite-bearing tactite adjacent to a biotite quartz monzonite contact. The tactite occurs in pods up to 10 ft wide. Scheelite was most commonly found in a relatively sulfide-free calc-silicate schist that was of lower grade than the tactite. Traces of molybdenite occur in quartz veins, pegmatite, and aplite dikes. No well-developed quartz stockworks were observed. Magnetic surveys show calc-silicate country rock to be more magnetically susceptible than granitic rocks. One magnetic anomaly of 1,700 gammas within calc-silicate schist coincided with a group of anomalous soil samples high in W, Mo, Pb, Cu, and Zn. Research done by the Alaska Field Operations Center. Available for reference at Bureau of Mines facilities in Anchorage, Fairbanks, and Juneau, AK; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 81-83. Hydrologic and Erosional Characteristics of Regraded Surface Coal Mined Land in Colorado, by W. D. Striffler and R. Allan Rhodes. Dec. 31, 1981. 119 pp. 15 figs. Land disturbed by surface mining in Colorado and other Western States has increased substantially over the past several years and is likely to increase even more in the future. This study was initiated to provide basic information on hydrologic and erosional characteristics of regraded coal spoils in Colorado as an aid for planning future reclamation activities. Of 21 surface mines licensed in Colorado, 11 were sampled during the summers of 1980-81. Mines not sampled included those that had not progressed to the point that reclamation had begun and mines where operators denied permission to sample. All coal regions were sampled except the San Juan Coalfield. Physical and hydrologic characteristics of regraded coal spoils in Colorado were determined using standard field and laboratory procedures. Field sampling included characterization of sites (slope, vegetation density, proportion of surface rock, bare soil, etc.) and infiltration measurements using a 1-m² drop former raining on a 1/2-m² rectangular plot frame. Core samples were analyzed for saturated hydraulic conductivity, bulk density, organic matter, moisture retention, and texture. The erosion potential of each site was determined using the Universal Soil Loss Equation. Results of the sampling indicate that infiltration rates vary widely both within and between sites. Research done under grants G5105062 and G5195010 by the Colorado State University. Available for reference at Bureau of Mines facilities in Denver, CO, and Spokane, WA; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 82-83. Hydrogeologic Aspects of Flyash Disposal Sites in Missouri, by Allen W. Hatheway. Mar. 28, 1983. 54 pp. 36 figs. Coal-fired utility generation stations in Missouri and the near environs of Kansas and Illinois have a production capacity of more than 12,546 megawatts of electricity. Annual

consumption of coal for these plants is believed to be in excess of 23 million metric tons; most of which is midwestern and of a relatively high sulfur content. The stations produce unique forms of waste that are classified as "special" wastes by the Environmental Protection Agency. Their mineralogical character is probably the most important aspect of the fly ashes, bottom ashes and slags, and flue-gas desulfurization wastes. Most of the wastes are produced in the extreme heat of the powerplant furnaces or in the stream of hot stack gases. Most of the concern for accessory pollutants comes from elements that are carried as surface coatings on these generally fine particles. The main objective of the current research is to provide a single source assessment of the hydrologic status of utility waste disposal sites in the Missouri coal-fired electric generation region. Research done under grant G1114028 by the University of Missouri—Rolla. Available for reference at Bureau of Mines facilities in Avondale, MD, Twin Cities, MN, and Rolla, MO; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 83-83. Radionuclide and Heavy Metal Distribution in Recent Sediments of Major Streams in the Grants Mineral Belt, N.M., by Carl J. Popp, John W. Hawley, and David W. Love. March 1983. 214 pp. 102 figs. The major objective of this research was to determine the extent to which active uranium mining and milling operations in the Grants mineral belt of west-central New Mexico contribute excess trace metals and radionuclides to Rio Puerco and Rio San Jose sediments. Subsidiary objectives include the determination of the modes of sediment movements in the Rio Puerco-Rio San Jose drainage systems and determination of the age of deposits along and adjacent to the modern drainage channels. Procedures used to make these determinations include (1) geomorphic evaluation of the fluvial transport and depositional system and evaluation of loci of sediment deposition along the drainages, (2) historical documentation of loci of deposition to aid in determining the age of sediments, (3) field sampling and sediment characterization, (4) laboratory characterization of grain size and mineralogy of sediment samples, (5) laboratory determination of trace metals and radionuclide concentrations in sediments, and (6) laboratory determination of ages of sediments using radioactive cesium-137 and lead-210. Research done under grants G1115352 and G5105041 by the New Mexico Institute of Mining and Technology. Available for reference at Bureau of Mines facilities in Avondale, MD, and Reno, NV; Office of Assistant Director—Minerals and Materials Research, Bureau of Mines, Washington, DC; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 84-83. Extraction of Radionuclides From Low-Grade Ores and Mill Tailings, by Arpad E. Torma. Mar. 31, 1983. 85 pp. 19 figs. The present study demonstrates the possibility of development of efficient leaching processes for the extraction of uranium from a low-grade ore and for the removal of long half-life radionuclides, especially radium-226, from the leach residues in order to produce environmentally safe and radiochemically innocuous tailings. The report provides kinetic information, not previously available, for low-grade uranium ore leaching by sulfuric and hydrochloric acids and by sodium carbonate and bicarbonate leachants. Based

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upon a statistical experimental design, a generalized mathematical form was developed for the initial rate of uranium extraction as a function of the leaching parameters using a linear regression computation technique. A specific ion exchanger for the removal of radium-226 from leach solutions and actual neutralized tailings effluents was developed. This solid ion exchanger can be obtained through a simple treatment of commercially available organic resins. Research done under grants G1115353, G5105078, and G5195031 by the New Mexico Institute of Mining and Technology. Available for reference at Bureau of Mines facilities in Avondale, MD, Twin Cities, MN, Reno, NV, and Salt Lake City, UT; Office of Assistant Director—Mineral and Materials Research, Bureau of Mines, Washington, DC; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 85-83. Design Procedures for Coal Mine Tunnels, by Z. T. Bieniawski. Mar. 31, 1983. 49 pp. 14 figs. Although coal mine tunnels such as the main haulageways or roadways are the lifelines of coal mines, little attention has been paid to them in the United States in terms of preconstruction planning and design. This report summarizes the results of a 3-year research project aimed at improving the design procedures for coal mine tunnels. A new design approach was developed for this purpose and roof-support design charts were prepared for mine tunnels and their intersections. Analytical studies, "base friction" model experiments, and in situ rock stress measurements were performed during this research. Research done under grants G1115425, G5105083, and G5195042. Available for reference at Bureau of Mines facilities in Denver, CO, and Pittsburgh, PA; Office of Assistant Director—Mining, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-197624; paper copy price code A03.

OFR 86-83. Characterization and Processing of Coal Fired Copper Reverberatory Flue Dusts, by Srinivasan Raghavan and Aniedi Ette. January 1983. 56 pp. 23 figs. A detailed study of the physical and chemical characteristics of a flue dust sample from a coal-fired copper reverberatory furnace was carried out. The studies revealed that the majority of the copper in the flue dust is strongly associated with iron in the form of a cuprous ferrite, CuFeO_2 (delafossite). The flue dust has an extremely fine size distribution with 70% of the particles below 37 μm in size. The recovery of copper from the flue dust was investigated using an ammoniacal carbonate solution. The results indicate that a reductive roast prior to leaching is necessary to obtain high extractions. In order to better understand the leaching characteristics of the flue dust, attempts were made to synthesize and study the leaching of the main copper-bearing constituent, CuFeO_2 . The dissolution of the CuFeO_2 was found to depend on the extent of reduction, particle size, and stirring speed. A film diffusion model was proposed to describe the kinetics of leaching of CuFeO_2 . Research done under grants G5105012 and G5115042 by the University of Arizona. Available for reference at Bureau of Mines facilities in Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, and Salt Lake City, UT; Office of Assistant Director—Minerals and Materials Research, Bureau of Mines, Washington, DC; and National

Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-197707; paper copy price code A04.

OFR 87-83. Beneficiation of Low Grade Appalachian Iron Ores To Recover Enriched Iron Concentrates, by H. S. Hanna and I. J. Anazia. Dec. 20, 1982. 126 pp. 49 figs. The feasibility of applying fine grinding and fine particle processing technology, as practiced in the Lake Superior region, to the low-grade, high-phosphorus red iron ores of the southeastern Appalachian region to recover iron ore products of a quality suitable for smelting competitively with imported materials is discussed. The application of new or improved processing technology or approaches embracing extremely fine grinding to achieve maximum liberation of the iron oxides and gangue constituents also is discussed. The research involved two principal lines. One emphasized the development of fundamental data relating to the fine grinding, sizing, and liberation characteristics of the ores to gain a better understanding of the most effective beneficiation approaches for separating the iron oxide and gangue minerals. The second focused on determining the merits of various beneficiation methods or combined techniques that would yield maximum recoveries of plus 60% iron products. Among the techniques applied were flotation, selective flocculation, reductive roasting and magnetic separation, magnetic flocculation, and hydrocyclone concentration. Research done under grants G1105056, G5105056, and G5195002 by the University of Alabama. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, and Twin Cities, MN; Office of Assistant Director—Minerals and Materials Research, Bureau of Mines, Washington, DC; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 88-83. Workshop—Cyanide From Mineral Processing, ed. by Jerry L. Huiatt, James E. Kerrigan, Ferron A. Olson, and Gary L. Potter. February 1983. 112 pp. 8 figs. A workshop on cyanide use in the minerals industry, sponsored by the Bureau of Mines, the National Science Foundation, the minerals industry, and supporting industries, was held on February 2-3, 1982, at the Bureau's Salt Lake City (Utah) Research Center. The workshop focused on use of cyanide as it relates to the gold and silver mining industry and the froth flotation processes employed by mineral mining companies. The intent was to discuss state-of-the-art technology and provide information pertinent to cyanide use in the minerals industry. No attempt was made to advocate regulatory limits or set policy governing the use of cyanide. The principal topics of discussion included (1) chemistry and use of cyanides, (2) control and treatment of cyanide mining wastes, (3) toxicity of mining wastes, (4) fate of cyanide in the environment, and (5) the analytical chemistry of cyanide. The problems associated with cyanide use in the mining industry and areas where technical information is insufficient were identified. The types of research required to understand and resolve potential adverse environmental problems were also identified. The problems and research needs are mentioned in a special summary to this document. Research done under contract J0113087 by the University of Utah. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Office of Assistant Director—Mining Research and

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Office of Assistant Director—Minerals and Materials Research, Bureau of Mines, Washington, DC; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 89-83. Fly Ash Pelletization, by Douglas W. Fuerstenau and Vikram P. Mehrotra. June 1982. 76 pp. 27 figs. The use of pulverized coal for power generation results in the production of vast amounts of fly ash in the United States. This research is concerned with the role of the physico-chemical characteristics of fly ash in governing its pelletization and the strength of the product pellets in relation to their potential use as lightweight aggregate. The potential impact of the research is extremely great in that a severe environmental problem may be alleviated by converting a huge mineral waste into a resource. Although results on batch and locked-cycle pelletization tests have indicated that it is possible to produce pellets of adequate strength from fly ash, appropriate and precise control of operation conditions is vital. Particle packing characteristics and the pozzolanic nature of ash have been identified as the important factors controlling the pelletization moisture and pellet growth. Pellet strength properties were found to be related to the amount of active silica and lime in the ash, the curing conditions, and the final products of hydration reactions. A thorough understanding of the control of continuous pelletization circuits must be developed if products of uniform quality are to be produced. Research done under grant G5105059 by the University of California. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Avondale, MD, and Albany, OR; Office of Assistant Director—Mineral and Materials Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-201889; paper copy price code A05.

OFR 90-83. Investigation of Microbially Induced Permeability Loss During In-Situ Leaching, by Corale L. Brierley and James A. Brierley. Apr. 16, 1982. 71 pp. 10 figs. Accumulations of microorganisms in the in situ leaching environment are believed responsible for plugging of the ore body and thus decreasing uranium extraction. To assess the contribution of microbial growth to this problem, packed columns of ore and core specimens were leached in the laboratory. Samples collected at four in situ uranium mining operations revealed pseudomonads, Xanthomonads, *Bacillus* sp. and *Micrococcus* sp. These microorganisms, inoculated into simulated leaching conditions, decreased permeability in two uranium ores by one order of magnitude in 20 days. Hydrogen peroxide alleviated microbial plugging in the laboratory. Periodic injection of hydrogen peroxide through the production well into the ore body may reduce microbial plugging problems in the field. Research done under contract S0211032 by the New Mexico Institute of Mining and Technology. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-205534; paper copy price code A04.

OFR 91-83. Development of Improved Scrubbers for Coal Mine Applications, by D. Grigal, G. Ufken,

J. Sandstedt, M. Blom, and D. Johnson. July 1982. 124 pp. 63 figs. The objective of this four-task program was to develop smaller, less expensive scrubbers while maintaining or improving scrubber efficiency and reliability. The development included (1) building a scrubber test facility suitable for testing contract-developed and future scrubber systems, (2) develop and test four fibrous-bed panels and two water droplet eliminators to reduce scrubber size and clogging, (3) fabricate and test two fibrous bed panels for use with the Bureau of Mines rotating, flooded-bed scrubber system, and (4) develop and test water-powered scrubber and recycle water systems for use at low water pressures. Tests revealed that the standard water droplet eliminator and the 20 double-layer fibrous-bed panels were the best choices for scrubber improvement. Based on clogging and pressure drop tests, it was recommended using 16 double layers of knitted wire mesh in the rotating scrubber. Research done under contract H0199055 by the Donaldson Co., Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; U.S. Department of Energy, Pittsburgh, PA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-205385; paper copy price code A06.

OFR 92-83. Preparation and Evaluation of Self-Regenerative Carbon Monoxide Detection Gels, by John G. Palmer, Michelle Cecil, Gerhard N. Schrauzer, and Kurt E. Shuler. September 1982. 51 pp. 7 figs. Continued development of an especially impregnated silica gel capable of reversible chemical detection of carbon monoxide was reported. The effects of changes in mine-related ambient conditions on the detection catalyst's response were explored. Temperature, humidity, and several interfering gases were found to affect the detection catalyst. The interferents include hydrogen sulfide, nitrogen dioxide, acetylene (and methylacetylene), and ammonia. High humidity decreased the detection catalyst's sensitivity to carbon monoxide for some formulations. Increasing temperature generally decreased the reaction time of the detection catalyst with carbon monoxide. A limited physical, chemical, and mechanistic characterization of the detection catalyst and the materials used to prepare it has been carried out. Metal component ratio studies, spectral, analytical, pH, and rate measurements were done. Research done under contract J0188159 by the University of California—San Diego. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-205179; paper copy price code A04.

OFR 93-83. Cable Fault Locator Research, by C. A. Cole, S. K. Honey, J. P. Petro, and A. C. Phillips. July 1982. 128 pp. 45 figs. This work consists of research in cable fault location and the construction of four field test units based on the research. Swept-frequency sounding of mine cables with radio frequency (RF) signals has been the technique most thoroughly investigated. The swept-frequency technique is supplemented with a form

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of moving target indication to provide a method for locating the position of a technician along a cable and relative to a suspected fault. Separate, more limited investigations involved high-voltage time domain reflectometry and acoustical probing of mine cables. Particular areas of research included microprocessor-based control of the swept-frequency system, a microprocessor-based fast Fourier transform for spectral analysis, RF synthesizers, transmit-receive switches, RF receivers, cable dispersion-compensation techniques, low-voltage multielement display systems, and techniques for injecting or recovering RF energy through cable walls in support of clamp-on fault locators. Research done under contract H0166082 by SRI International. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-205393; paper copy price code A07.

OFR 94-83. A Hydrogen Engine Induction Technique for Backfire-Free Operation, by Ned Baker and Frank Lynch. May 30, 1982. 46 pp. 24 figs. Details are given of a fuel-induction system for a hydrogen-fueled engine. The induction system was designed to preclude backfire otherwise common in hydrogen-fueled engines. System features and test data are presented and discussed in the context of the requirements peculiar to use in an underground mine environment. The fuel-induction system, when tested in conjunction with a modified Caterpillar 3304 engine, provided backfire-free engine operation and satisfactory engine performance. Research done under contract H0202034 by EIMCO Mining Machinery International. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-205443; paper copy price code A03.

OFR 95-83. Personal Dust Monitor—Light Scattering, by Pedro Lillienfeld and Roger Stern. November 1982. 40 pp. 13 figs. The objective of this program was the development, design, and fabrication of six personal-sized, completely self-contained dust monitors capable of real time as well as time-averaged monitoring of the concentration of respirable particles in coal mines in the range of 0.1 to 100 mg/m³. The operation of these monitors is based on light scattering and passive air sampling. The design stressed overall miniaturization, ruggedness, simplicity, and versatility. These instruments incorporate a single-chip CMOS microprocessor to perform all signal processing, data display and storage, and timing functions. The overall dimensions of these devices are approximately 10 by 10 by 5 cm. Research done under contract H0308132 by GCA Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV;

and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-205435; paper copy price code A03.

OFR 96-83. A Study of Explosion-Proof Enclosures, by P. A. Cox, O. H. Burnside, E. D. Esparza, F. D. Lin, and R. E. White. December 1982. 426 pp. 204 figs. The purpose of the initial research performed under this contract was to determine the margins of safety in explosion-proof (XP) enclosures that were designed and certified according to Schedule 2G. Results from this work provide baseline data on the current schedule, from which a new schedule can be formulated to give equal or greater levels of safety. Results and discoveries in the initial work led to an expansion of the contract to cover, additionally, weld quality in enclosure fabrication, reliability of enclosures with windows and lenses, and performance tests for enclosure qualification. Finite element calculations and hydrostatic tests revealed wide variations in the margins of safety in the enclosures studied; however, only one enclosure had a safety factor of less than one. Results from a weld quality survey led to the recommendation of AWS Welding Standard D14.4 for the fabrication of XP enclosures. Based on other work, accelerated aging tests were recommended for qualifying plastics and adhesives that are used in some enclosures, and a structural performance test was developed to test enclosure strength for a minimum static pressure of 150 psig. Research done under contract H0377052 by the Southwest Research Institute. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-205450; paper copy price code A19.

OFR 97-83. Study of Stability Problems and Hazard Evaluation in the Missouri Portion of the Tri-State Mining Area, by Michael C. McFarland and James C. Brown, Jr. Apr. 30, 1983. 141 pp. 39 figs. A 2-year investigation disclosed 469 hazardous sites resulting from past zinc-lead mining in the vicinity of Joplin, MO. Aerial-photo analysis, fieldwork, library research, and personal interviews were conducted to locate and describe the abandoned mining areas and their associated hazards. Open shafts, subsidence pits, and other mine-related dangers exist in areas easily accessible to the public. Accidents involving humans and livestock have been reported. Some recent damage to buildings and roads can be attributed to the collapse of underground mine workings. A few landowners have employed successful methods of safeguarding dangerous sites. In addition, some surface reclamation has been effected by gradual removal and use of mine and mill waste-rock, with subsequent leveling and reuse of the land. Other than backfilling shafts, nothing has been done to stabilize undermined areas. A continuing problem is indicated. Under present laws, most government reclamation funds are designated for coal-mined lands. A comprehensive program of hazard control and monitoring for the entire study area is warranted. Research done under contract J0100132 by the Missouri Department of Natural Resources, Division of Geology and Land Survey. Available for reference at Bureau of Mines facilities in Denver, CO, Rolla, MO, and Pittsburgh, PA; National Mine Health and Safety Academy, Beck-

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ley, WV; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 98-83. Evaluation of Charged Water Sprays for Dust Control, by J. McCoy, J. Melcher, J. Valentine, D. Monaghan, T. Muldoon, and J. Kelly. January 1983. 151 pp. 38 figs. Charged sprays and fog were evaluated for reducing respirable dust concentrations. Charged spray technology was reviewed for effectiveness, equipment, and theoretical considerations. A mathematical model was developed for predicting dust reduction effects. Laboratory tests were made showing charged spray is considerably more effective at reducing dust on a unit water basis than hydraulic spray. Positive and negative sprays are equally effective. Combined polarity sprays are considerably less effective than either polarity alone. Little difference in effectiveness by dust type was observed. The charged cloud can present a spark hazard in explosive atmospheres; therefore, this technique must not be used in gassy mines. Predictions were made for field test conditions but confirmation was impossible because of particles resulting from dissolved solids in the spray water. Dissolved or suspended solids in atomizing sprays can result in an increase of the respirable dust burden. Charged sprays are an available dust control technique best suited to applications where water usage must be limited and long contact time between spray and dust is possible. Research done under contract H0212012 by Foster-Miller, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-210476; paper copy price code A08.

OFR 99-83. An Observational Study of Classroom Health and Safety Training in Coal Mining, by R. Michael Digman and John T. Grasso. April 1982. 65 pp. 3 figs. This study was concerned with the quality and effectiveness of existing classroom coal mine health and safety training programs. The study involved field data collection through pre- and posttesting of trainees, audiotaping class sessions, and administering short feedback forms with trainers and trainees at 14 sites in West Virginia, Maryland, Kentucky, and Pennsylvania. Results indicate that goals, methods, materials, and outcomes of existing training programs vary widely among trainers and sites. The report provides less by way of solution to problems than it highlights the breadth of issues that relate to the question of training effectiveness and quality. The report concludes that additional work by industry, labor, government, and academia is necessary to improve health and safety programs. Recommended steps are (1) to develop performance standards and measurable criteria in each of the types of mandated training, (2) to develop better training of trainers, (3) to develop expanded training support services, and (4) to undertake further research and development in health and safety training in the mining industry. Research done under contract J0188069 by the West Virginia University. Avail-

able for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-210518; paper copy price code A04.

OFR 100(1)-83. Evaluation of Proximity Warning Devices. (Phase III, Volume 1), by J. H. Nixon, J. E. Hipp, T. C. Green, G. H. Munsch, and J. P. Cater. Dec. 31, 1982. 91 pp. 46 figs. A three-phase program evaluated commercial proximity warning devices, developed and designed a microprocessor-based electrostatic field measurement instrument, and utilized the instrument to investigate the electrostatic fields about powerlines. Phase I consisted of test evaluations of these commercially available proximity devices. Phase II resulted in the design and development of a microprocessor-based distributed sensor ac electrometer that measures the electrostatic field at 17 discrete locations along a crane boom. Under the phase III program, electrostatic fields around a crane boom were measured by the instrument at 17 high-voltage powerlines of various voltages and geometries. The data were processed and plotted versus boom distance from the powerlines. Analysis of the data indicate that the distances at which a single sensor alarm will activate vary by a factor of 3 to 1, due primarily to variations in boom orientation. The results also indicate that in the case of multiple powerlines, a single electrostatic field sensor cannot reliably be used to determine the distance from a powerline. Research done under contract J0188082 by Southwest Research Institute. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, and Pittsburgh, PA; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-210260; paper copy price code A05.

OFR 100(2)-83. Evaluation of Proximity Warning Devices. (Phase III, Volume 2), by J. H. Nixon, J. E. Hipp, T. C. Green, G. H. Munsch, and J. P. Cater. Dec. 31, 1982. 311 pp. 277 figs. Phase I of this three-phase program consisted of test evaluations of commercially available proximity warning devices. Phase II resulted in the design and development of a microprocessor-based distributed sensor ac electrometer that measures the electrostatic field at locations along a crane boom. In volume 1 of phase III the electrostatic fields around a crane boom were measured by the instrument at high-voltage powerlines of various voltages and geometries. Volume 2 of phase III contains the appendixes. Research done under contract J0188082 by Southwest Research Institute. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, and Pittsburgh, PA; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-210278; paper copy price code A14.

OFR 101-83. Catalysis of Chlorination Reactions, by Y. K. Rao. May 5, 1982. 24 pp. 11 figs. The objective of this research was to determine the feasibility of catalyzing the chlorination of alumina using inex-

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pensive catalytic substances. The chlorination kinetics of alumina in the presence of carbon were investigated for different forms of carbon and two different alumina particle sizes. The influence of catalysts such as ternary, NaF, and cryolite were studied for different carbon materials. The following observations were noted: (1) sodium fluoride appears to be the most stable catalyst, (2) ternary catalyst is quite powerful initially but its catalytic activity diminishes gradually possibly because of progressive deactivation, and (3) cryolite is an intermediate catalyst that may be more desirable than NaF in industrial applications. Research done under grant G1105054 by the University of Washington. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Avondale, MD, Twin Cities, MN, and Salt Lake City, UT; Office of Assistant Director—Mineral and Materials Research, Bureau of Mines, Washington, DC.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 102-83. Computer Simulation of Mining Subsidence Using the Zone Area Method, by M. Karmis and C. Haycocks. March 1983. 95 pp. 43 figs. The objective of this research was to develop a computer model of subsidence prediction based on the zone area method. This technique was chosen because of its potential to investigate a mining plan of any shape, thus facilitating subsidence prediction over longwall as well as room-and-pillar coal mining systems. A comprehensive subsidence data bank was established that included published as well as unpublished information on subsidence measurements. Based on these studies, some fundamental characteristics of longwall subsidence were established, and this information was utilized to develop an empirical prediction method. The established relationships were also used for the formulation and subsequent testing of the modeling procedures. The results and comparisons of the study demonstrated that the zone area method has considerable potential for accurate, rational, and flexible subsidence predictions. Research done under grants G1105051 and G1115512 by the Virginia Polytechnic Institute and State University. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 103-83. Probabilistic Modeling of Soil Loss From Surface Mined Areas, by K. B. Rojiani, K. A. Tarbell, V. O. Shanholtz, and F. E. Woeste. Apr. 28, 1983. 77 pp. 24 figs. The goal of this study was to provide a rational basis for selecting a sediment control system for surface mine regions that would minimize the chance of exceeding effluent standards set by regulatory agencies for total sediment yield. A probabilistic model to predict storm sediment yield and sediment yield over the lifetime of the mining operation was developed. This model can be used to predict sediment yield for a given period of occurrence that can subsequently be used as a basis for the design of sediment control structures. Probability distributions of sediment yield were determined by coupling probabilistic models of rainfall amount, duration, and time between storms with a deterministic event-based model of the sediment yield process. A modified universal

soil loss equation formed the basis for the deterministic sediment yield model. Runoff volume and peak flow were computed using the Soil Conservation Service runoff curve number method. Using probabilistic analysis procedures and a simulation approach sediment yield probability, distributions were determined for individual storm events and for the lifetime of the mining operation. Research done under grant G1115514 by the Virginia Polytechnic Institute and State University. Available for reference at Bureau of Mines facilities in Denver, CO, Avondale, MD, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 104-83. A Low-Cost Landsat Digital Technology Training Package, by John A. Harrington, Jr. May 1983. 49 pp. 17 figs. The purpose of this report is to document a computer-assisted instruction package developed to facilitate instruction of computer-based, interactive, image processing of remote sensor data. The computer software was designed for a low-cost Apple II+ microcomputer and four-channel Landsat digital data. Utilization of this educational package should extend the availability of college-level instruction concerning multi-spectral digital image analysis in remote sensing, especially since this technology is now coming into research and commercial application in the mining and mineral industries. Research done under grant G1195039 by the University of Oklahoma. Available for reference at the Bureau of Mines facility in Avondale, MD, and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 105-83. The Competitive Position of the United States Copper Industry: 1980-2000, by Patricia T. Foley and Joel P. Clark. Oct. 29, 1982. 306 pp. 9 figs. An engineering-economic model was used to determine the effects that U.S. State tax actions can have on U.S. copper mines operating in a world market. The copper model used in this report is based on site- and input-specific data for 65 copper operations in the United States and site-specific data for 348 copper operations in the rest of the world. These data are used to develop world shortrun and longrun supply functions that are equated with an econometric estimate of world demand and solved for price and production under various tax scenarios. The shortrun analysis included currently producing mines; deposits for which the development decision has been made and for which the financing has been arranged are included in the longrun analysis. Research done under grants G5105029 and G5115253 by the Massachusetts Institute of Technology. Available for reference at Bureau of Mines facilities in Avondale, MD, and Salt Lake City, UT; Office of Assistant Director—Minerals Data Analysis, Bureau of Mines, Washington, DC; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 106(1)-83. The Effects of Increasing Energy Costs on the Future Relation Between Open Pit and Underground Mining. Volume I: Chapters 1-10, by Dan S. Nilsson. December 1982. 253 pp. 67 figs. The objective of this study was to evaluate the energy

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consumption in some open pit and underground mines and to show the optimal proportion between open pit and underground mining for different types of commodities. The results show (1) the future relation between open pit and underground mining of different types of deposits, (2) the future competitiveness between large-scale mining of low-grade ore and small-scale mining of high-grade ore, (3) actual power consumption figures for different mining activities, and (4) guidelines for a more energy-efficient mining industry. The study provides a base for forecasting mine production of different commodities and for decisions about how to spend research money and organize education in the field of mining engineering. Volume I contains chapters 1 through 10. Research done under grant G5105032 by Michigan Technological University. Available for reference at Bureau of Mines facilities in Denver, CO, and Avondale, MD; Office of Assistant Director—Minerals Data Analysis and Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-216515, paper copy price code A12.

OFR 106(2)-83. The Effects of Increasing Energy Costs on the Future Relation Between Open Pit and Underground Mining. Volume II: Chapters 11-17, by Dan S. Nilsson. December 1982. 216 pp. 43 figs. The objective of this study was to evaluate the energy consumption in some open pit and underground mines and to show the optimal proportion between open pit and underground mining for different types of commodities. The results show (1) the future relation between open pit and underground mining of different types of deposits, (2) the future competitiveness between large-scale mining of low-grade ore and small-scale mining of high-grade ore, (3) actual power consumption figures for different mining activities, and (4) guidelines for a more energy-efficient mining industry. The study provides a base for forecasting mine production of different commodities and for decisions about how to spend research money and organize education in the field of mining engineering. Volume II contains chapters 11 through 17. Research done under grant G5105032 by Michigan Technological University. Available for reference at Bureau of Mines facilities in Denver, CO, and Avondale, MD; Office of Assistant Director—Minerals Data Analysis and Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-216523; paper copy price code A10.

OFR 107-83. Control of Blackwater in Coal Preparation Plant Recycle and Discharge, by P. A. Rey, R. Hogg, and F. F. Aplan. Apr. 29, 1983. 38 pp. 6 figs. Water recycle is an important part of the coal preparation process. This study was directed toward (1) a survey of current practice and an evaluation of both the solid and liquid components of blackwater, (2) an experimental study of blackwater flocculation, and (3) a fundamental analysis of the flocculation process. The solids contained in the blackwater discharge to the fine refuse thickener of a coal preparation plant were found to contain, on average, 56% coal and 44% mineral matter. The mineral matter was largely illitic clay, while the water phase contained relatively large amounts of SO_4^- and Ca^{++} . Detailed studies were

made of both natural and synthetic flocculants and the influence of polymer type and pH on the settling rate, turbidity of the supernatant liquid, and sludge volume of the settled solids. More fundamental studies were made that clearly indicate the need for controlled mixing of polymer into the suspension to be flocculated and the need to evaluate more closely the structure of the flocs formed during the process. Research done under grants G1115424, G5105082, and G5195041 by the Pennsylvania State University. Available for reference at Bureau of Mines facilities in Denver, CO, and Pittsburgh, PA; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-216481; paper copy price code A03.

OFR 108-83. Flotation Properties and Selective Flotation of the Slightly Soluble Minerals, by F. F. Aplan and M. Castillo. March 1983. 27 pp. 7 figs. Separation of the slightly soluble minerals, $K_{sp} \sim 10^{-10}$, is one of the more difficult tasks confronting flotation engineers. This study focused on means of separating such prominent members of this class as scheelite, fluorite, and calcite from one another. Some experimental work was also done on magnetite, dolomite, and apatite. Four techniques were evaluated for separation of the minerals: (1) control of potential determining ions, (2) use of stereospecific collectors, (3) use of flotation rate differences, and (4) use of selective activating and depressing compounds. Each of these techniques was found to be a possible method of achieving selectivity between scheelite, fluorite, and calcite. The use of stereospecific fatty acid or sulfonate collector appears to be a particularly promising method of achieving selectivity between minerals of the slightly soluble class. Research done under contract J0199162 by the Pennsylvania State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Office of Assistant Director—Minerals and Materials Research, Bureau of Mines, Washington, DC; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-218412; paper copy price code A03.

OFR 109-83. Incorporation of Fire Extinguishing Agents in High Expansion Foam, by S. S. Gross. July 1982. 34 pp. 9 figs. A program was conducted to determine whether sufficient quantities of the flame retardant, ammonium phosphate, could be incorporated in a water-based foam solution to prevent or delay reignition (burnback) without significant degradation of foam properties. Up to 20% of mono-ammonium and diammonium phosphate was added to a high-expansion foam solution. This mixture was applied to burning wood and coal samples. The effect of the mixture on burnback was laboratory tested by placing the wood or coal sample in front of a radiant panel. It was found that diammonium phosphate levels of 20 wt-pct prevented reignition without degrading foam properties. A field test was then conducted using a 20% diammonium phosphate mixture and a control with no phosphate on a wood crib fire. The experimental foam did extinguish the crib fire faster than the control as evidenced by the smoke from the crib; however, neither crib reignited. Research done under contract H0308064 by MSA Research Corp. Available for

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reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-218859; paper copy price code A03.

OFR 110-83. Personal Equipment for Low Seam Coal Miners:

VIII. Improved Traction Rubber Boot Soles, by Mark S. Sanders and Jacqueline V. Downing. October 1982. 26 pp. 3 figs. Based on laboratory and preliminary field tests of off-the-shelf steel-toed rubber boots, a molded sole design was developed to provide increased traction over conventional calendared sole miners' boots. The pattern provided sharp edges perpendicular to both lateral and fore-aft slip vectors. The sole was designed to reduce mud caking. An in-step lace-up capability was added to better secure the foot inside the boot. A 5-month field evaluation compared the prototype boots to the boots the participants usually wear. Although objective slip and fall data showed no significant advantage for the prototype, subjective evaluations made by the participants indicated increased traction for the prototype boots. Approximately 75 percent preferred the prototype to their own boots. Approximately one-third used the lace-up capability. It was concluded that molded soles provide better traction than calendared soles for the underground mining environment. Research done under contract J0387213 by the Canyon Research Group, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-218594; paper copy price code A03.

OFR 111-83. Development of a Prototype Retrofit Noise Control Treatment for Jumbo Drills, by

Nicholas R. Dixon and Matthew N. Rubin. July 1982. 106 pp. 70 figs. The noise and vibration levels of four jumbo drills were characterized and a survey of percussive rock drill usage is reported. A Gardner-Denver DH 123 drill was chosen as a demonstration drill, and extensive noise diagnostic studies were performed. Noise control treatments were designed, developed, and evaluated in a reverberant drill test facility. The treatments consisted of an integral enclosure-muffler for the drifter, vibration isolation of the drifter from the enclosure and feed, and a drill steel sheath. A 19-dBA reduction in overall sound power level was achieved with no loss in drilling rate. The prototype retrofit treatments were field tested in an aboveground mine and in a production section of an underground zinc mine. Long-term durability and operator acceptance of the enclosure-muffler treatment were excellent. Preliminary evaluation of the drill steel sheath was encouraging, although additional testing is required. Research done under contract H0387006 by Bolt Beranek and Newman Inc. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Min-

ing Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-218800; paper copy price code A06.

OFR 112-83. Dust Control on Active Tailings Ponds, by

Russel R. Bohn and Jeffrey D. Johnson. February 1983. 124 pp. 42 figs. The objectives of this study were to (1) determine the state of the art for the control effectiveness of various chemical dust suppressants, (2) field test the effectiveness of the dust suppressants, and (3) develop technical guidelines for selecting and implementing cost-effective tailings pond dust control programs. Chemical stabilizers evaluated under field conditions were Coherex, calcium lignosulfonate, Nalco 656 and 655, and magnesium chloride. Testing in the field utilized a portable field in situ wind tunnel. The wind tunnel was placed on the tailings surface, and simulated wind speeds up to 80 mph were used to determine wind erosion threshold velocities. Emission rate testing was performed with the wind tunnel through the use of a real-time cascade impactor. A control cost-effectiveness evaluation was performed to determine how efficient the chemical stabilizers were on a dollars expended per acre basis. Research done under contract J0218024 by Environmental Services & Technology. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-216382; paper copy price code A06.

OFR 113-83. Improving Check Curtains, Line Curtains and Extensible Face Ventilation Systems, by T.

Muldoon, P. Bartlett, and W. Schroeder. November 1982. 112 pp. 56 figs. A fieldworthy 10-ft extensible brattice to maintain a 10-ft setback was found in use in two mines on continuous miner faces. The technique was evaluated in the laboratory for leakage and methane control at the face. Significant results include the following: (1) Air leakage through a gap in the extensible curtain depends upon the ratio of the cross-sectional areas between entry and return as well as gap area, (2) gap shape has no significant effect on methane concentrations at the face—increasing gap area diminishes ventilation effectiveness, and (3) substantial reductions of CH₄ concentrations at the face were accomplished by brattice extensions with gaps up to 5 ft² in area. An inby hook, inserted in the roof automatically to make possible the deployment of a longer brattice extension in the context of a remotely controlled miner, was tested in various roof types. Insertion of this design succeeded only in coal. Research done under contract J0100075 by Foster-Miller, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-216242; paper copy price code A10.

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OFR 114-83. Development of a Slurry Filling System for Modified In Situ Oil Shale Mining, by E. A. Ziemba, G. H. Watson, P. H. Bissery, D. L. Namy, P. Pfister, and R. L. Griffis. March 1982. 190 pp. 74 figs. The modified in situ process is one of the methods being considered for extracting oil from oil shale. One of the questions to be answered for this approach is the environmental consequence of underground retort abandonment. This report outlines a study that addresses the question in terms of a grouting solution. The report covers the development of a spent shale-ash-based grout that will fulfill the environmental requirements in terms of strength, stability, and impermeability. In addition, the grout will allow the reinjection of up to 50 percent of material mined and surface retorted as part of the process. Research done under contract J0295046 by Rio Blanco Oil Shale Co. and Soletanche & Rodio, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Office of Assistant Director—Mining, Bureau of Mines, Washington, DC; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-216374; paper copy price code A09.

OFR 115(1)-83. Development of an Improved Man Transit Vehicle. Volume 1. Prototype Demonstration Vehicle, by Bruce Pinkston and William F. Hahn. January 1981. 81 pp. 17 figs. This report presents a description of a prototype demonstration vehicle that was constructed to assess the feasibility of a set of equipment-related guidelines. State-of-the-art improvements were embodied in such areas as collision survivability, occupant comfort, and multiple-mode operation. The electric battery-powered vehicle carries a 12-person section crew at speeds up to 12 mph. The description of the demonstration vehicle is presented in volume 1. Research done under contract J0366003 by Booz, Allen & Hamilton Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-218156; paper copy price code A05.

OFR 115(2)-83. Development of an Improved Man Transit Vehicle. Volume 2. Safety Guidelines, by Bruce Pinkston and William F. Hahn. January 1981. 124 pp. This report presents a description of a prototype demonstration vehicle that was constructed to assess the feasibility of a set of equipment-related guidelines. State-of-the-art improvements are embodied in such areas as collision survivability, occupant comfort, and multiple-mode operation. The electric battery-powered vehicle carries a 12-person section crew at speeds up to 12 mph. Safety guidelines are presented in volume 2. Research done under contract J0366003 by Booz, Allen & Hamilton Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and National Library of Natural Resources, U.S. De-

partment of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-218164; paper copy price code A06.

OFR 116-83. Management and Supervisory Training: Review and Annotated Bibliography, by Joseph A. Olmstead and Devah R. Galloway. June 1980. 83 pp. Literature concerned with management and supervisory training was reviewed and analyzed from the perspective of relative effectiveness of various training methods for improving knowledge and awareness, changing attitudes, improving problem-solving skills, improving interpersonal skills, and improving on-the-job performance. Conclusions were drawn relative to each method and the current state of the field of management and leadership training. A 168-item annotated bibliography is presented. Research done under contract J0188053 by the Human Resources Research Organization. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: AD-A102589; paper copy price code A05.

OFR 117-83. Portable Dynamic Brake Testing Apparatus for Mobile Underground Mine Equipment, by Martin Smirlock and Mark Tanquary. December 1981. 166 pp. 40 figs. A novel instrumentation system was developed that enables simple, quick, and accurate measurement of vehicular dynamics within low-speed ranges. The system, consisting of a microwave transceiver and microprocessor data acquisition and reduction system, measures the deceleration dynamics of low-speed mining and construction equipment. It makes the basic measurement; calculates key parameters such as average deceleration, initial velocity, stopping distance, and brake system delay time; and produces autoscaled graphs of velocity, acceleration, and displacement versus time. Research done under contract H0308033 by Foster-Miller Associates, Inc. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-218511; paper copy price code A08.

OFR 118-83. Automated Cableless Face Haulage Vehicle, by T. M. Heinrich. Aug. 27, 1979. 108 pp. 34 figs. An automated haulage system is described that utilizes existing battery-powered face haulage vehicles modified such that they follow a guidepath defined by an electrically excited wire fixed to the mine roof. Rerouting of the haulage paths is accomplished by simply reconnecting the guidewires. The development of the system was carried out through a design phase, and the impact on safety, productivity, and cost effectiveness was studied. Research done under contract H0155103 by Westinghouse Electric Corp. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy,

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Beckley, WV; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-220988; paper copy price code A06.

OFR 119-83. Driver Alertness Monitoring System for Large Haulage Vehicles, by Slade F. Hulbert,

Robert J. Dompe, and James L. Eirls. November 1982. 120 pp. 11 figs. A driving simulator for large haulage vehicles (100+ tons capacity) was designed and assembled to conduct experiments leading to the definition of prototype driver alertness monitoring and driver warning systems for installation on-board operating vehicles for in-mine tests and evaluation. The truck-mounted system would monitor driver performance and physical condition-behavior to determine onset of unalertness that could lead to an accident. The report describes the large truck simulator, tests using the simulator on driver subjects, and the specifications for on-board driver alertness monitoring and driver warning system for in-mine testing. Research done under contract H0282006 by Tracor MBA. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-220640; paper copy price code A06.

OFR 120-83. Mine Hoist Operator Training and Information Processing Workload, by Richard Rosenblatt, Paul Loustaunau, and Devah Galloway.

August 1982. 97 pp. 2 figs. This report describes a training program for mine hoist operators and a human factors study on the possibility of an information processing overload in mine hoist operators. The first effort addresses formalizing and accelerating the process of hoist operator training. This was achieved through the collection of task data, development of training objectives, specifications of controlled training exercises, and development of requisite training materials. Validation results are presented. The second effort, addressing hoist operator overload, investigated the potential overload of the hoist operator's abilities to process information and control the hoist. Data were gathered in the field during periods when the probability of operator overload was greatest. The data were analyzed and the conclusions drawn therefrom are presented. Research done under contract H0387003 by the Human Resources Research Organization. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-220434; paper copy price code A05.

OFR 121-83. Alumina Extraction From Anthracite Culm With Energy Recovery, by Robert P. Apa, Earl S. Grimmer, F. Ralph Keller, and John N. McFee.

Sept. 21, 1982. 86 pp. 14 figs. The objective of this program was to develop a process to recover alumina and energy from northeastern Pennsylvania

anthracite culm. The program located culm banks of sufficient size and quality to support a commercial plant. The method of using a fluidized bed to process the ore for alumina and energy recovery was demonstrated to be technically feasible. The fluidized bed can tolerate large fluctuations in both carbon and ash contents without affecting alumina recoverability. Based on the tests, a conceptual design was prepared and is included in this report. Based upon 1982 values for alumina and electricity, a facility of this magnitude has a marginal economic return. Increases in either the market value of alumina or the sale price of electricity may provide economic justification for the construction of such a facility in the near future. Research done under contract J0215022 by Energy Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Avondale, MD, Twin Cities, MN, Reno, NV, Rolla, MO, Albany, OR, and Salt Lake City, UT; U.S. Department of Energy, Pittsburgh, PA; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-220897; paper copy price code A05.

OFR 122-83. Novel Cab Design Concepts To Improve Large Haulage Vehicle Safety, by Glenn E. Adkins,

John L. Dahle, and Lawrence Owens. November 1982. 152 pp. 47 figs. The objective of this work is to improve the safety potential associated with off-highway haulage truck operations. The report describes the development and evaluation of seven novel cab location concepts for large off-highway haulage trucks. A preliminary design of a completely novel truck configuration is also described. An analysis of 1978-79 haulage truck accidents as well as the fundamental parameters of haulage truck design, operation, and selection are presented. Research done under contract J0295013 by Woodward Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA; Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-221085; paper copy price code A08.

OFR 123-83. Design of an Extended Bumper for Mine Haulage Trucks, by John L. Dahle, Lawrence Owens, and Glenn E. Adkins.

May 15, 1981. 88 pp. 40 figs. This report presents extended bumper designs for 170-ton rear-dump haulage trucks used in the mining industry. The extended bumper designs are to provide operator protection in the event of rear-end collisions between two trucks. The bumper designs are a result of studying critical truck characteristics important in rear-end collisions and haulage truck accident data, as well as the dynamics of a collision. In addition, existing extended bumper designs were analyzed and evaluated. Research done under contract J0215003 by Woodward Associates, Inc. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-221515; paper copy price code A05.

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OFR 124-83. Fatalities in Small Underground Coal Mines, by National Academy of Sciences. May 1983. 20 pp. 2 figs. The National Academy of Sciences, in a prior report "Toward Safer Underground Coal Mines," identified a strong correlation between mine size and fatality rate. That work showed that the fatality rate in mines with fewer than 50 employees was nearly three times that of large mines (those who employ over 250 employees). The current report determines why small mines have a higher fatality rate. The high rate is contributed to several factors that include (1) the intermittent mode of small mine operation, (2) insufficient financial resources, and (3) inadequacies in the training of workers and managers. It was also determined that 85 pct of all small mines are concentrated in Virginia, West Virginia, and Kentucky. It is recommended that the governments of these three States should provide assistance to small mine operators in the form of advice on safety. Research done under contract J0100145. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 125(1)-83. Technological Innovation in the Copper Industry. Volume I. Methodology, by Alfred Weiss, Nicholas Themelis, and Nellie Guernsey. March 1983. 58 pp. 7 figs. The objective of this report was to develop and apply a methodology to quantitatively assess the probability and potential benefits of technological innovation over the next 25 years to solve copper industry problems in the United States. Volume I describes the methodology procedures used to survey the opinions of experts, analyze the findings, and prepare the report. Research done under contract J0100063 by Mineral Systems Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-227066; paper copy price code A04.

OFR 125(2)-83. Technological Innovation in the Copper Industry. Volume II. Technology Forecast, by Alfred Weiss, Nicholas Themelis, and Nellie Guernsey. March 1983. 137 pp. 29 figs. The objective of this report was to develop and apply a methodology to quantitatively assess the probability and potential benefits of technological innovation over the next 25 years to solve copper industry problems in the United States. Volume II presents the consensus technology forecast of the experts surveyed in the study. Research done under contract J0100063 by Mineral Systems Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-227074; paper copy price code A07.

OFR 125(3)-83. Technological Innovation in the Copper Industry. Volume III. Cost/Benefit Analysis, by Alfred Weiss, Nicholas Themelis, and Nellie Guernsey. March 1983. 91 pp. The objective of this report was to develop and apply a methodology to quantitatively assess the probability and potential benefits of technological innovation over the next 25 years to solve copper industry problems in the United States. Volume III provides estimates of the net present value cost effectiveness of each technology assessed under both optimistic and pessimistic scenarios. Research done under contract J0100063 by Mineral Systems Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-227082; paper copy price code A05.

OFR 126-83. Propagation of EM Signals in Underground Metal/Non-Metal Mines, by Terry S. Cory and Richard J. Mahany. Aug. 20, 1981. 266 pp. 142 figs. This report describes the results of a measurement and analysis program to characterize wireless radio transmission in metal-nonmetal mines over a wide frequency range from 0.2 to 1,000 MHz and over a variety of mine environments. Six mines were chosen based on the relative economic significance of their product to the U.S. economy. Mine types include oil shale, uranium, potash, lead-zinc, copper, and silver. Particular mines were chosen to embody the most important mining techniques of the group. The results show that transmission at medium frequencies are optimum for wireless mine communications, agree with extensive testing previously performed in coal mines, and that minewide wireless systems are feasible with a minimum requirement for new dedicated wiring. Research done under contract J0308012 by Terry S. Cory. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; and the National Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-234666; paper copy price code A12.

OFR 127-83. Evaluation and Acceptance Criteria for Innovations in Explosionproof Electrical Enclosures, by R. J. Gunderman. March 1982. 141 pp. 25 figs. A conventional trailing cable connection box on a continuous mining machine was modified by the addition of two innovative devices: A pressure vent to preclude buildup of high pressure caused by an explosion inside the enclosure and a grommet-type cable entry to simplify and speedup cable entering procedures. The devices were evaluated for 8½ months in a working section of an underground coal mine. Laboratory tests before and after the in-mine exposure show no measurable change in the devices. Following the favorable in-mine evaluation, technical performance criteria were defined to serve as the basis of approval for the use of the devices. Additional tests to measure comparable gripping of the cable by asbestos rope, substitution rope materials, and by the urethane grommet-type entry were included. Also, literature covering the last 80 years was searched. Comments are provided as to how the devices comply with 30 CFR Part 18. Research done under contract H0357107 by Jeffrey Mining Machinery Div., Dresser Industries, Inc. Available for reference at Bureau of Mines facilities

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in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-233379; paper copy price code A07.

OFR 128-83. Investigation of the Mechanics of Mine Acid Formation in Underground Coal Mine Drainage, by Fraser M. Walsh. July 1982. 69 pp. 3 figs. The objective of this program was to determine by laboratory experiments the kinetics and mechanics of the reactions that produce acid in coal mine drainage. The program was divided into three phases: In phase I, five coal mines, representative of Appalachian coal mines, were chosen for sampling and an experimental design was identified suited to accomplish the program objectives. In phase II, the five mines were sampled and test protocols applied. The results showed most pyrite weathering to be based on oxidation in the presence of water. Iron bacteria, especially *Thiobacillus ferrooxidans*, catalyzed the rate of pyrite weathering by a factor of three. An increase in initial iron concentration in a system that modeled the mine environment acted to inhibit bacterial catalysis of weathering. In phase III, five tailings piles were sampled and the material obtained was used to evaluate this method of bacterial catalysis inhibition. The evaluation verified method effectiveness; inhibition over 80% of the release of weathering was observed. Research done under contract J0887215 by ECO, Div. of KOR, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; U.S. Department of Energy, Pittsburgh, PA; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-233387; paper copy price code A04.

OFR 129-83. Assessment of a 40-Kilowatt Stirling Engine for Underground Mining Applications, by James E. Cairelli, Gary G. Kelm, and Jack G. Slaby. June 1982. 75 pp. 54 figs. The National Aeronautics and Space Administration (NASA) Lewis Research Center performed an assessment of alternative power sources for the Bureau of Mines. As part of this assessment, NASA tested a 40-kW Stirling research engine to evaluate its performance and emission characteristics when operated with helium working gas and diesel fuel. This report describes the engine, the test facility, and the test procedures. Performance and emission data for the engine operating with helium working gas and diesel fuel are reported and compared with data obtained with hydrogen working gas and unleaded gasoline fuel. Helium-diesel test results are compared with the characteristics of current diesel engines and other Stirling engines. External surface temperature data are also presented. Emission and temperature results are compared with Federal requirements for diesel underground mine engines. The durability potential of Stirling engines is discussed on the basis of the experience gained during the engine tests. Research done under contract J0100026 by NASA Lewis Research Center. Avail-

able for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: N82-30714; paper copy price code A04.

OFR 130-83. Effects of Engineering Parameters on the Control of Respirable Dust, by R. L. Rankin, S. J. Rodgers, and E. V. Polite. November 1982. 49 pp. 4 figs. Field studies were conducted on eight continuous miner sections and two longwall sections operating in five different coal seams. Data and information on dust concentrations and engineering dust controls were acquired for normal operations. Dust concentrations at the mine operator and longwall face locations were evaluated using gravimetric samplers and instantaneous dust monitors. Engineering dust controls that were evaluated included airflow rates and/or velocities, waterflow rates and/or pressures, brattice distances, and face cutting times or rates. An analysis of the data acquired during the field studies was performed using multiple regression methods. Several relationships describing the influence of dust control parameters upon dust levels of mining equipment operators are presented. The effects of engineering dust controls upon miner operator dust concentration may be expected to be different from mine to mine and sometimes from section to section. A consistent relationship between the dust concentration variations and dust control variations was not observed. Research done under contract J0887226 by MSA Research Corp. Div., Mine Safety Appliances Co. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-232207; paper copy price code A04.

OFR 131-83. Safety and Health in Underground Mine Waste Disposal, by J. P. Schmid, M. R. Schmidt, G. J. Colaizzi, and R. H. Whaite. December 1982. 221 pp. 23 figs. Results of a comprehensive investigation of the impact of underground mine waste disposal on the health and safety of miners are presented. Information was gathered through an extensive search of U.S. and foreign literature and personal communication with professionals in private industry and government. All conceivable health and safety hazards directly or indirectly related to underground mine waste disposal are analyzed, categorized, and ranked on an industry-wide basis. Positive health and safety effects are analyzed and ranked in a similar way. Both potential and known hazards and positive impacts are included. Recommendations on abatement techniques for the various hazards are presented. Case histories of a fill-related accident in a metal mine and a health hazard associated with coal waste backfilling are included and causes and possible abatement procedures are discussed. The role of management in the promotion of health and safety in backfilling operations is discussed. Research done

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under contract H0218021 by Goodson & Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-232140; paper copy price code A10.

OFR 132-83. Direct Smelting of Lead Sulfide, by Y. K. Rao.

June 1983. 94 pp. 53 figs. The extraction of lead from lead sulfide by a direct-smelting process that is free of sulfur oxide emissions was investigated. The process involved reducing lead sulfide with carbon in the presence of limestone. Under the conditions employed, limestone dissociates readily into lime and carbon dioxide. The limestone is the active desulfurizing agent that fixes the sulfur in the charge by forming CaS residue. The investigation focused on the measurement of reduction kinetics in the temperature range of 768° to 1,026° C. The reduction of PbS in the presence of lime using CO-CO₂-N₂ gas reductant was also studied. The kinetics of both the catalyzed and uncatalyzed reduction processes were investigated. The catalyst used is an equimolar ternary eutectic (K,Na,Li)₂CO₃ that has a relatively low melting point of 397° C. Research done under contract J0205011 by the University of Washington. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 133-83. Development of Environmentally Attractive Leachants. Volume I, A Minitest for In Situ Uranium Leaching, by Robert S. Schechter, Larry W. Lake, and Muhammad I. Kabir. Jan. 31, 1983. 314 pp. 80 figs. This report describes a minitest consisting of a central injection production well surrounded by at least two observation wells designed to detect the arrival of injected fluid, leached minerals, and nonideal flow. The goals of the test are to determine the susceptibility of the host formation for uranium leaching, to establish important kinetic parameters so that the results of the minitest can be used to correctly scale the process, and to identify those factors that may render site restoration difficult. The report considers nonidealities such as reservoir permeability heterogeneities, nonuniform mineral distribution, and minerals other than uranium that may react with the leach solution. To circumvent these difficulties, methods of interpretation were proposed and tested by analysis of realistic data generated by a computer simulator. Clear-cut methods of interpretation were not found in the more complex cases, but in every case the design of an optimum test was considered and recommendations made. Research done under contract H0282016 by the University of Texas at Austin. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-234497; paper copy price code A14.

OFR 134-83. Mine Waste Location by Satellite Imagery, by Michael A. Anuta and Om P. Babethi. December 1982. 100 pp. 19 figs. This report describes the potential for utilization of satellite observations for remote sensing of mine waste disposal areas. Four study sites consisting of metal and nonmetal mining areas in different climatic and physiographic regions of the contiguous United States were used in the investigation. The mine waste disposal sites consisted of mining of phosphates in Florida, copper in Arizona, silver in Idaho, and coal in West Virginia. Landsat satellite multispectral scanner observations were used together with aerial photographs, ground surveys, U.S. Geological Survey maps, and other ancillary information. Landsat digital data were categorized using automated supervised classification algorithms and an image analysis system. Detailed descriptions of automated classification techniques employed and the accuracy attained are provided together with the results of manual interpretations. The inventory of areas disturbed for phosphate mining and a change detection investigation for Polk County, FL, were also undertaken during the study. Research done under contract J0208030 by Science Systems and Applications, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-238519; paper copy price code A05.

OFR 135-83. Critical Parameters for Tailings Embankments, by Gregory B. Baecher, W. Allen Marr, J. S. Lin, and John A. Consla. January 1983. 282 pp. 186 figs. Geotechnical data on copper, uranium, and phosphate tailings from 41 mines were collected and analyzed to empirically establish the variability in strength properties for tailing embankments. These data were analyzed both from geotechnical and statistical perspectives to infer typical strength parameters for slope stability analysis. The results indicate large variability of strength properties both within and among tailings embankments. However, this variability in most cases appears statistically regular and tends toward normal distributions when spatial trends are removed. The implication is that probabilistic techniques can be used to assess the importance of strength property variability for embankment stability and that the assumption of common distributional forms for input to such modeling is appropriate. Research done under contract J0215028 by Baecher, Marr and Associates. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-238394; paper copy price code A13.

OFR 136-83. Technique for Determining Efficiency of Sorbents in Diffusion-Type Samplers, by E. D. Palmes. March 1983. 28 pp. 2 figs. Phase I of this study demonstrated the feasibility of measuring the efficiency and capacity of sorbents in tube samplers for contaminant gases. This was accom-

plished by measuring the concentration of a known gas in the tube sampler and comparing it to the concentration of the same gas in a tube sampler containing a known quantity of sorbent. The results of this study are presented in a separate report (OFR 137-83). Research done under contract J0215028 by Baecher, Marr and Associates. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-238394; paper copy price code A13.

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plished by measuring concentration at various points along the length of the diffusion path during sampling by removing small aliquots with gas-tight syringes and injecting them into a gas chromatograph. With hexane as the gas and activated charcoal as the sorbent, the procedure was successful. Phase II involved application of the principle to gases of importance in diesel exhaust using a variety of sorbents. High concentrations of the test gas clearly demonstrated the differences in both efficiency and capacity of the sorbent for each of several gases. The chief drawbacks of the system were that efforts to determine more toxic gases at realistic occupational exposure levels or to determine formaldehyde at any level using the flame ionization detector were unsuccessful. It was concluded that, although the method is feasible, ore-sensitive methods of measuring concentrations of gas in the tube must be developed to make the procedure applicable to regions of chief industrial hygiene interest. Research done under contract J0308072 by the New York University Medical Center. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-236190; paper copy price code A03.

OFR 137-83. A Simulation Model for Predicting the Performance of Vibrating Screens, by Kevin Hennings and Doug Grant. December 1982. 120 pp. 44 figs. Screening efficiency models developed to date rely almost exclusively on empirical formulas based upon large amounts of acquired operating data. A screening model was developed using a combination of empirical coefficients and explicit mathematical expressions that quantify screening phenomena. A series of screening tests was run to supply data for purposes of correlation and empirical coefficient evaluation. The model was implemented as a digital computer program. The validity of the modeling procedure was established by laboratory testing. The results were used to compile an applications handbook that can be used to predict screening performance instead of using the computer program. Research done under contract J0395138 by Allis-Chalmers Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-238386; paper copy price code A06.

OFR 138-83. Removal of Pyrite From Coal by Heap Leaching, by L. M. Cathles and K. J. Breen. June 1983. 287 pp. 34 figs. The feasibility of leaching pyrite from coal heaps is analyzed by adapting a model of the heap-leaching process developed in the copper industry. Parameters in the model are first determined through literature review and direct measurement. The model is then used to predict how coal fragments will leach in reaction kettles containing ferric sulfate solution, in columns through which air is circulated, and in actual heaps. Model parameters are verified and refined by kettle and column experiments. The

model is then used to determine the optimum heap size and operating procedures. Eight-foot heaps of ¼-inch coal fragments leach best. The average rate of application of flush solutions should be less than 0.01 gal/ft²-hr. It should be possible to leach more than 90% of the finely disseminated pyrite from the coal in 9 months, providing the flush solutions are recirculated. Removal of pyrite from coal utilizing such a process is economically attractive. A heap-leaching operation capable of depyritizing 1 million tons of coal per year has a positive net present value at discount rates up to 16% (base case) to 33% (best case). Research done under grants G1115427, G5105007, and G5115007 by the Pennsylvania State University. Available for reference at Bureau of Mines facilities in Denver, CO, Avondale, MD, Pittsburgh, PA, and Salt Lake City, UT; Office of Assistant Director—Mining Research, and Office of Assistant Director—Mineral Data Analysis, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-238758; paper copy price code A13.

OFR 139-83. Leaching of Bornite With Oxygen and Ferric Chloride as Oxidants, by Ferron A. Olson. June 11, 1982. 183 pp. 98 figs. Natural bornite (Cu₅FeS₄) leached in ferric chloride or in sulfuric or hydrochloric acid solutions with oxygen showed several differences. In ferric chloride 80% of the copper was leached in two stages. The first was controlled by liquid ferric ion diffusion and chemical surface reaction and required 1 minute for a 30% copper removal. The second was controlled by formation of a surface sulfur layer and then diffusion through the sulfur. With oxygen in sulfuric acid, reaction was slow and only the first stage was studied. Copper removal had an induction period. The bornite structure disappeared at 12% copper removal (also found with ferric chloride) and covellite formed on the surface with a species inside the particles with an X-ray structure similar to CuFeS₂ but with Cu₃FeS₃ composition and ferric chloride. Copper removal was controlled by iron dissolution. Surface iron vacancies filled with Cu⁺ to give CuS while interior copper dissolution produced Cu₃FeS₄. Preliminary results with oxygen and hydrochloric acid showed 80% copper removal and sulfur as end products. Research done under grant G0284001 by the University of Utah. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, and Albany, OR; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-234997; paper copy price code A09.

OFR 140(1)-83. Development and Fabrication of a Continuous Miner Training System. Volume 1, by C. W. Morris, E. H. Conklin, and F. J. Bick. August 1982. 64 pp. 6 figs. This report describes the major technical activities that were accomplished to produce a comprehensive continuous miner training system (CMTS) for coal industry utilization. The primary product of this program was a continuous miner part-task trainer. It is composed of an interactive computer graphics system combined with the operating controls of a continuous mining machine mounted in a simulated cab. The cab contains an audio system for reproducing continuous miner operational sounds. The trainer is supplemented with a complete set of cognitive materials that provide instruction in the operation, safety, and health of continuous miner operations. A complete summary of the field test and evaluation of

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the CMTS is provided along with recommendations for further training program refinements, expansions, and utilization. Research done under contract H0377025 by McDonnell Douglas Electronics Co. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 140(2)-83. Development and Fabrication of a Continuous Miner Training System. Volume 2, by C. W. Morris and E. Conklin. August 1982. 79 pp. 18 figs. The continuous miner training system provides classroom materials, training aids, and a continuous miner simulator to provide a short, intensive instruction and skills development program for training or retraining continuous miner operators. The project included refinement of training objectives, revision of training aids, improvements to the simulator, and evaluation of the entire system. This report describes the revised materials and the validation of the training system. Research done under contract H0377025 by McDonnell Douglas Electronics Co. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 141-83. Particle Dispersion in Fine Mineral Flotation, by Maurice C. Fuerstenau. July 1982. 58 pp. 29 figs. Studies on the composition of aluminum hydroxy silicate polymer were undertaken using gel filtration chromatography. Preliminary analysis indicates that 14 to 17 silicon atoms to 1 aluminum atom are contained in the polymer. Optimal pH for formation is between 5.5 and 6.5. Electrokinetic and microflotation studies on pure minerals were undertaken to establish mechanisms of aluminum hydroxy silicate adsorption and to determine the effect that this dispersant exhibits on flotation response. The polymer chemisorbs on chrysocolla, chalcopyrite, and chalcocite but does not interfere with flotation even with relatively large additions. Dispersion of finely divided particles with aluminum hydroxy silicate sol results in improved recovery in copper flotation systems. Copper recovery is increased by 4.9 pct from an oxide ore and 2.1 pct from a sulfide ore in the presence of low additions of aluminum hydroxy silicate sol. Research done under contract J0295077 by the South Dakota School of Mines and Technology. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Avondale, MD, Rolla, MO, Reno, NV, Albany, OR, and Salt Lake City, UT; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-238360; paper copy price code A04.

OFR 142-83. The Impact of Surface Lignite Mining on Surface- and Ground-Water Quality in Texas, by C. C. Mathewson, K. W. Brown, L. E. Deuel, and D. G. Kersey. August 1982. 84 pp. 28 figs. The impact of surface mining of Texas lignites on surface and ground water systems was investigated. Surface water and/or hydrogeologic analysis were conducted at two active and three proposed mines in the Texas lignite belt. Field and laboratory studies measured the infiltration characteristics of

surface mined land, determined the quality of surface water runoff, and analyzed the hydrogeologic impacts of surface mining on ground water quality and quantity in resaturated mine spoil. Adverse impacts of surface mining were found to be minimal in deltaic and coastal lagoon lignite deposits, which have shale-rich overburden; disturbances to the hydrologic balance were negligible. Mining of fluvial lignites associated with thick aquifer sands may result in degraded ground water quality and quantity, but long-term impacts are projected to be minimal. Runoff from mined land is similar to that from unmined native soils; both have high suspended loads. Research done under contract J0295016 by Texas A&M University. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-238378; paper copy price code A05.

OFR 143-83. Demonstrating the Noise Control of a Coal Preparation Plant. Volume II: Long Term Treatment Evaluation, by Matthew N. Rubin. June 1982. 91 pp. 56 figs. The purpose of this work was to obtain operational data on retrofit noise control treatments suitable for use in coal preparation plants. These data were obtained by evaluating the performance of four categories of noise control treatments (resilient screen decks, resilient impact pads, chute liners, and curtains) that were installed in a commercial coal preparation plant. The selection, installation, and initial evaluation of the treatments were presented in volume I of the report. Volume II, the present work, summarizes the results of the long-term evaluation of the original treatments, as well as some additional tests that were conducted on elastomer-clad (resilient) screen decks. The project demonstrated the feasibility of a number of retrofit noise control treatments, some of which also proved to be quite durable over the long term. Research done under contract H0155155 by Bolt Beranek and Newman Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-237354; paper copy price code A05.

OFR 144-83. Scaling in Geothermal Systems: Investigations of Geothermal Brines of the Salton Sea Area, by H. L. Barnes, J. D. Rimstidt, D. O. Hayba, and J. B. Murowchick. December 1978. 223 pp. 55 figs. The objective of this research was to develop an understanding of the fundamental processes involved in the formation of geothermal scales. One step toward this understanding involves compiling available data on brine composition and temperatures. Also, chemical and mineralogical analyses of scales that have precipitated from these brines under known and controlled conditions are necessary. To obtain especially documented samples, field tests were developed and performed to simulate the scale-forming processes. Laboratory studies of the thermodynamic and kinetic characteristics of silica-water reactions were carried out. Silica was emphasized because it is the most common, pervasive, and bothersome scale component. The resulting insights

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into the physical chemistry of the scale-forming processes are presented here together with some of their implications for scale prevention. Research done under grant G0155140 by the Pennsylvania State University. Available for reference at Bureau of Mines facilities in Avondale, MD, and Reno, NV; Office of Assistant Director—Minerals and Materials Research, Bureau of Mines, Washington, DC; and National Library of Natural Resources, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 145-83. Point Defects in Hydrometallurgical Processes, by G. Simkovich and K. Osseo-Asare. June 1983. 16 pp. 9 figs. This project investigated the effect of point defects on hydrometallurgical processes of mineral dissolution. Samples of NiO, ZnO, α -Fe₂O₃, and CuO that were doped with lower and higher valent dopant cations showed significant changes in dissolution rate when compared with that of the pure compound. Doping and stoichiometry control in ZnS, however, have a lesser effect when compared with the specific interaction from copper ions. Research done under grants G1115426, G5105084 and G5195040 by the Pennsylvania State University. Available for reference at Bureau of Mines facilities in Avondale, MD, Rolla, MO, Reno, NV, and Salt Lake City, UT; Office of Assistant Director—Minerals and Materials Research, Bureau of Mines, Washington, DC; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 146-83. Applications of Image Processing to the Comminution of Fine-Grained Complex Sulfide Ores, by J. R. Craig, R. M. Haralick, and R. H. Yoon. June 1983. 244 pp. 59 figs. This investigation was directed toward a detailed study of the comminution of complex sulfide ores from the Eastern United States. The first part deals with laboratory batch grinding experiments in which several different ore samples are characterized in terms of rate of breakage and breakage distribution functions. Using these parameters, the batch grinding experiments are simulated by the ESTMILL program. In the second part, both pulverized and uncrushed ore samples are examined using an optical microscope, with the images processed by a computer. A software package named the General Image Processing System (GIPSY) was adapted and expanded to process the optical images and to characterize the ore samples and mill products. Finally, the image analysis data are compiled to determine the degree of liberation of the various minerals present in the complex sulfide ores. Research done under grants G51105052 and G1115513 by the Virginia Polytechnic Institute and State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Avondale, MD, Rolla, MO, Reno, NV, Albany, OR, and Salt Lake City, UT; Office of Assistant Director—Minerals and Materials Research, Bureau of Mines, Washington, DC; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 147-83. Development of Chromium-Free Grades of Constructional Alloy Steels, by Carl J. Keith and V. K. Sharma. May 15, 1983. 60 pp. 26 figs. The objective of this research was to develop a new series of cost-effective chromium-free steels. The new steels are intended to be capable of adoption by a broad range of industry as a substitute for the

chromium-containing 8600 and 4100 standard grades of heat-treated constructional alloy steels. Based upon several socioeconomic scenarios and their projected impacts on alloying element cost and availability in 1985, a computerized metallurgical design system was used to design two substitute steels for each of the standard grades. Both steels, a manganese-molybdenum substitute and a manganese-nickel-molybdenum substitute, are expected to provide heat-treat response and mechanical properties equivalent to the 8600 and 4100 steels. Small, experimental heats of the chromium-free replacement steels were prepared and their hardenability response and mechanical properties were evaluated and compared with the base-line 8620 steel. Research done under contract J0113104 by the International Harvester Co. Available for reference at Bureau of Mines facilities in Avondale, MD, Rolla, MO, Albany, OR, and Pittsburgh, PA; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-243873; paper copy price code A04.

OFR 148-83. Evaluation of Novel Coal Cutting Concepts for Reduced Dust Generation, by Robert W. Decker. July 1981. 147 pp. 38 figs. This report presents a survey of published novel cutting (mining) concepts along with a brief discussion of each. A preliminary evaluation follows that identifies promising concepts, emphasizing reduced dust generation and economic production potentials. The promising concepts are then studied more deeply and evaluated in more detail with recommendations given for further development action. Research done under contract J0199065 by Ingersoll-Rand Research, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-243717; paper copy price code A07.

OFR 149-83. Copper Sulfide Flotation in an Air-Sparged Hydrocyclone, by David J. Kinneberg and Jan D. Miller. May 1983. 85 pp. 25 figs. The concentration of a low-grade porphyry ore by froth flotation in a 4.7-cm-diam air-sparged hydrocyclone was investigated. The effects of important design and operating variables on the separation efficiency were examined. The variables included slurry feed rate, airflow rate, pulp density, cell length, wall porosity, and kerosene additions. Several modifications to the basic design of the air-sparged hydrocyclone were also studied. A comparison of performance of the air-sparged hydrocyclone with conventional flotation for this particular ore showed that remarkably short retention times were required to achieve satisfactory separations. Moreover, preliminary data indicated that the recovery of molybdenum and gold with the air-sparged hydrocyclone was comparable with that obtained in a conventional cell. It was concluded that the air-sparged hydrocyclone has the potential to significantly alter conventional copper rougher or scavenger circuits, although additional research will be required before this potential can be realized. Research done under grants G1105049 and G1115492 by the University

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of Utah. Available for reference at Bureau of Mines facilities in Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, and Salt Lake City, UT; Office of Assistant Director—Minerals and Materials Research, Bureau of Mines, Washington, DC; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-253526; paper copy price code A05.

OFR 150-83. Ground Control in Multi-Level Room and Pillar Mines, by William G. Pariseau. June 1983. 122 pp. 36 figs. This research is concerned with ground control in multiseam mining and relates mainly to the analysis of stress about multi-seam room-and-pillar mines. The two variables of most concern are distance between seams and alignment of the pillars between seams. The first efforts of the investigation apply to the development phase of mining when the extraction is typically less than 50%. The second efforts are concentrated on retreat mining and barrier-pillar safety when the extraction is typically greater than 50%. The procedures in both cases are readily applicable to more than two seams. Although two-seam mines are the most frequent type of multiseam operations, because of the potential for three-seam operations in the Western United States, a number of three-seam development analyses are also presented. Research done under grants G11105048 and G1115491 by the University of Utah. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-252965; paper copy price code A06.

OFR 151(1)-83. Development of a Procedure for Land Use Potential Evaluation for Surface-Mined Land. Final Report, by Raja V. Ramani and Richard J. Sweigard. Jan. 31, 1983. 116 pp. 18 figs. Productive and beneficial use of reclaimed surface-mined land is a concern of industry, Government, and the general public. An investigation was conducted on current mined-land practices to aid in the development of a procedure to evaluate postmining land use potential that considers both industry and public approaches. A detailed review of the impact of regulations, factors that determine land use, and current site planning methods employed by the mining industry is included. The investigation included three in-depth case studies of surface mines in the Eastern, Central, and Western United States. A site planning process was developed and applied to the studies to evaluate the economic, environmental, and social impacts of postmining land use alternatives. In addition, guidelines were proposed to enhance the cooperation between local land use planners and surface-mine planners, as well as to improve comprehensive planning with regard to mineral resources at the local and regional levels. Research done under grants G1115428, G5105085, and G5195043 by the Pennsylvania State University. Available for reference at Bureau of Mines facilities in Denver, CO, Avondale, MD, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the

Interior, Washington, DC. Order ONLY from NTIS: PB 83-253401; paper copy price code A06.

OFR 151(2)-83. Development of a Procedure for Land Use Potential Evaluation for Surface-Mined Land. Appendix I: Eastern U.S. Surface Mine Case Study, by Raja V. Ramani and Richard J. Sweigard. Jan. 31, 1983. 89 pp. 30 figs. The potential usefulness of reclaimed surface-mined land has received much attention in recent times. This is partially because of the establishment of Federal environmental reclamation standards, but concern for achieving better land uses has also been shown by interested members of the mining industry. In an effort to develop a procedure for evaluating postmining land use potentials, specific mines in various regions of the United States were studied to determine the extent of current mined-land planning and to discover characteristics that are regional in nature. As part of this investigation, a 430-acre surface mine in Clearfield County, PA, was studied. Established site planning principles were applied to the study site including formation of a data base, development of alternate land use plans, and evaluation of the economic, environmental, and social impacts of the land use alternatives. Key factors affecting site realization were identified along with positive suggestions for applying land use planning processes to mined-land planning. Research done under grants G1115428, G5105085, and G5195043 by the Pennsylvania State University. Available for reference at Bureau of Mines facilities in Denver, CO, Avondale, MD, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-264325; paper copy price code A05.

OFR 151(3)-83. Development of a Procedure for Land Use Potential Evaluation for Surface-Mined Land. Appendix II: Central U.S. Surface Mine Case Study, by Raja V. Ramani and Richard J. Sweigard. Jan. 31, 1983. 137 pp. 38 figs. In an effort to develop a procedure for evaluating postmining land use potentials, specific mines in various regions of the United States were studied to determine the extent of current mined-land planning and to discover characteristics that are regional in nature. As part of this investigation, the Chinook Mine-West Field, located in western Indiana, was studied. The Chinook Mine is presently operated by AMAX Coal Co. and has been in continuous operation since 1928 under various ownerships. The status of current reclamation and land use planning was reviewed. In addition, site planning principles were applied to the active mine area that include the formation of a data base and development of postmining land use plan alternatives. Key factors affecting site potential realization for Midwestern area mines were identified along with suggestions for applying land use planning processes to mined-land planning. Research done under grants G1115428, G5105085, and G5195043 by the Pennsylvania State University. Available for reference at Bureau of Mines facilities in Denver, CO, Avondale, MD, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order

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OFR 151(4)-83. Development of a Procedure for Land Use Potential Evaluation for Surface-Mined Land.

Appendix III: Western U.S. Surface Mine Case Study, by Raja V. Ramani and Richard J. Sweigard. Jan. 31, 1983. 108 pp. 31 figs. In an effort to develop a procedure for evaluating postmining land use potentials, specific mines in various regions of the United States were studied to determine the extent of current mined-land planning and to discover characteristics that are regional in nature. As part of this investigation, the Indian Head Mine, which is located in Mercer County, ND, was studied. The Indian Head Mine is presently operated by American Coal Corp., Western Div., and has been in operation since 1917 under various ownerships. The status of current reclamation and postmining land use planning was reviewed. In addition, the relationship between mine planning and public planning in an area impacted by energy development was investigated. Finally, key factors affecting site potential realization for Western surface mines were identified. Research done under grants G1115428, G5105085, and G5195043 by the Pennsylvania State University. Available for reference at Bureau of Mines facilities in Denver, CO, Avondale, MD, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-264341; paper copy price code A06.

OFR 152(1)-83. Noise Attenuating Properties of Earmuffs Worn by Miners. Volume 1: Comparison of

Earmuff Attenuation as Measured by Psychophysical and Physical Methods, by Kenneth C. Stewart and Ernest J. Burgi. January 1980. 46 pp. 22 figs. This contract was directed toward a study of the attenuating properties of earmuffs as worn by miners. Two attenuation measurement procedures were utilized. Human subjects were tested in a diffuse sound field according to threshold shift procedures recommended by the American National Standards Institute and a physical measurement procedure was accomplished in the same diffuse field on the same subjects with microphones placed simultaneously on the inside and outside of the muffs. All measurements were obtained on 1/3 octave of random noise. The results indicated that physical and psychophysical attenuation measurements are in essential agreement at frequencies from 125 Hz to 2 kHz. Above 2 kHz the psychophysical measurement demonstrates larger amounts of attenuation than the physical measurement. The difference in attenuation ranged from approximately 7.0 to 9.0 dB at frequencies of 4 kHz and above. A possible explanation for the differences in attenuation is presented. Research done under contract J0188018 by the University of Pittsburgh. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-257063; paper copy price code A03.

OFR 152(2)-83. Noise Attenuating Properties of Earmuffs Worn by Miners. Volume 2: Development

of a Laboratory Procedure for the Physical Measurement of Earmuff Attenuation, by Kenneth C. Stewart and Ernest J. Burgi. June 1980. 37 pp. 17 figs. The purpose of this study was to develop and evaluate, in the laboratory, instrumentation and procedures that might allow for the use of physical measurements of earmuff attenuation that would yield results equivalent to those obtained from psychophysical measures of attenuation. The ultimate goal was to evaluate techniques that might subsequently prove feasible for physical measurement of earmuff attenuation in the field. Instruments currently in use were modified to have a response similar to differences observed in earmuff attenuation as observed in volume 1 of this report. Mining noise spectra were selected and presented to a single subject seated in a diffuse noise field wearing one of the muffs evaluated in the earlier study and fitted with two physical sound measurement systems. A linear system measured the outside noise level and a linear system plus correction filter measured the inside noise level. The measurement indicated that under the procedures presented in this report, a laboratory method for measuring earmuff attenuation is feasible and yields results comparable with an extensive psychophysical procedure. Research done under contract J0188018 by the University of Pittsburgh. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-257071; paper copy price code A03.

OFR 153-83. System Study of Mine Rescue Through Electromagnetic Means,

by Robert L. Lagace, James M. Dobbie, Gordon Raisbeck, Richard H. Spencer, Mark A. Degatano, Francis J. Lambiase, and N. Albert Moussa. October 1982. 181 pp. 1 fig. This report describes the results of a system study of factors influencing mine rescue attempts based on the use of electromagnetic VF (voice frequency) rescue transmitters by trapped miners and helicopter-borne search receivers by mine rescue personnel. The report covers four areas: (1) mine emergency and disaster considerations that concentrate on characterizing the events and key parameters of mine fires and explosions related to trapped miner location and rescue activities, (2) hardware considerations that concentrate on characterizing the relevant properties of VF rescue transmitters and search receivers; oxygen-type self-rescuers; and helicopter performance, signal detectability, and sensor sweepwidths, (3) a search theory probabilistic model that develops a method to identify the most important regions to be searched and to allocate helicopter-based search efforts to maximize the number of miners detected in time to be rescued, and (4) sensitivity analyses and application of the search model on representative mine emergency and disaster scenarios to assess the impact and effectiveness of helicopter-based searches. Conclusions and recommendations are presented, together with a set of search planning guidelines. Research done under contract J0113043 by Arthur D. Little, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK,

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Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-253393; paper copy price code A09.

OFR 154-83. Validation and Extension of Visibility Requirements Analysis for Underground Mining Equipment, by Mark S. Sanders and Gregory S. Krohn. January 1983. 65 pp. 25 figs. Six underground coal mine shuttle cars were used to assess visibility using visual attention locations (VAL) and an improved human eye reference measurement instrument (HERMI Mark II). Each machine was assessed in the inby and outby directions of travel without a canopy and with a canopy in its highest and lowest positions, enabling the illumination level at each VAL to be determined. The results showed that operator eye position was the most important variable determining visibility. When this variable is controlled, the addition of a canopy has no effect on visibility. Further, with the eye position controlled, there is no difference between high and low seam machines. The assessments showed blind spots on the opposite side of the car from the operator and ahead of the machine. The report includes suggestions to reduce the blind spots and a procedures manual for using HERMI Mark II and the system of VAL to assess visibility from underground mining equipment. Research done under contract J0318072 by the Canyon Research Group, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-252957; paper copy price code A04.

OFR 155-83. Evaluation of the Black River Mine Telecommunication System, by Dana T. Updyke and Howard C. Turnage. February 1983. 104 pp. 7 figs. An evaluation was made of one of several improved underground communication systems sponsored by the U.S. Bureau of Mines. The system was installed in a typical metal-nonmetal, room-and-pillar mine and utilized ultrahigh frequency repeaters connected to a unique distributed antenna and passive reflector system that provided minewide communications. A microprocessor-controlled data collection system was assembled and installed for the evaluation. Data consisting principally of times and durations of messages and identities of the originating transceivers were collected over a 6-month period. Analyses of these data show that the principal benefits are reduction in time required for unscheduled maintenance and repair, enhancement of safety, and better coordination of production activities. A cost benefit analysis shows a net benefit over cost, although it is also concluded that the capacity of the system is greater than can be justified by current activity in the mine. Research done under contract J0318074 by the Atlantic Research Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale,

MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-257097; paper copy price code A06.

OFR 156-83. Diesel Engines in Underground Mining: A Bibliography With Abstracts, compiled by Robert W. Waytulonis and Wanda J. West. April 1983. 443 pp. 1 fig. This publication contains 1,000 citations of technical and semitechnical literature treating diesel-powered equipment usage underground both generally and specifically. The citations were gathered by Bureau of Mines personnel during 1978-83. The citations concern diesel engines as powerplants for underground mining use; their design, emission characteristics and control, maintenance, and usage; and health and safety aspects. All of the citations have been abstracted and arranged in a subject classification system with extensive cross-referencing. Work done by the Bureau of Mines Twin Cities Research Center. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-258608; paper copy price code A19.

OFR 157-83. Use of Surfactants To Improve Oil Recovery, by W. Fred Ramirez. June 1983. 93 pp. 25 figs. The theory of optimal control of distributed parameter systems is presented for determining the best possible injection policies for enhanced oil recovery processes. The optimization criterion is to maximize the amount of oil recovered while minimizing injection costs. Necessary conditions for optimality are obtained through application of the calculus of variations and Pontryagin's Weak Minimum Principle. A gradient method is proposed for the computation of optimal injection policies. Research done under grant G1115081 by the University of Colorado. Available for reference at Bureau of Mines, Avondale, MD; U.S. Department of Energy, Bartlesville, OK; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 158-83. Develop Data for Review of Metal and Non-Metal Mine Methane Hazard Classification, by Alastair M. Lumsden and Richard Talbot. January 1983. 519 pp. 15 figs. A study was initiated to examine the ways in which a number of foreign countries classify and regulate metal and nonmetal mines that experience problems caused by naturally occurring flammable gases. Twenty countries were selected for study and useful information was obtained from 16. Nine countries were visited to hold meetings with representatives of government mine regulatory agencies and mine operators and to visit

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mines encountering methane, carbon dioxide, nitrogen, etc. Seven gassy metal and nonmetal mines in the United States were visited to provide a basis for comparison, and hence the evaluation of both U.S. and foreign gassy mine regulations. In addition to obtaining copies of the mining laws and regulations of a number of foreign countries, nine foreign and seven U.S. gassy mines were documented in as much detail as possible. Research done under contract J0100060 by Golder Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-258624; paper copy price code A22.

OFR 159-83. Heat-Pulse Anemometer for Measuring Air Velocities in the Range 0.4 to 7 Ft/Sec. Part I:

Development. Part II: Microprocessor-Based Instrument, by G. T. Skinner, M. G. Dunn, and R. J. Hiemenz. May 1982. 110 pp. 39 figs. This report describes the development of a portable low-speed heat-pulse anemometer for underground mine airflow measurements. Part I describes the development of the instrument. Various physical and electrical parameters such as wire diameter, spacing of the probe wires, operating temperature of the pulsed wire, signal processing and system control, ambient thermal properties, and flow alignment were varied in a successful effort to find a method of operating a heat-pulse anemometer over the range of air velocities from 24 to 390 ft/min. Part II describes the implementation of these findings in a personal, self-contained microprocessor-based instrument measuring 6 by 7 by 2½ in, with a sectioned 2-ft wand. Mechanical, aerodynamic, and electronic design details are given, and the software is documented. Research done under contract H0377029 by Calspan Corp. Advanced Technology Center. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-256917; paper copy price code A06.

OFR 160-83. Coal Fines Recovery and Utilization, by Juh W.

Chen, Albert C. Kent, and Charles B. Muchmore. May 1983. 134 pp. 33 figs. A process to recover energy from waste coal fines, developed through laboratory, bench, and pilot plant experiments, was investigated. The process consisted of mechanical cleaning followed by high-temperature oil agglomeration and pelletization. The process can produce a quality product under an economically and environmentally acceptable condition. Waste coal fines with ash less than 35% and high-heat value (HHV) greater than 6,000 British thermal units per pound (Btu/lb) were upgraded to a product with less than 15% ash and HHV greater than 11,500 Btu/lb. A computer model was developed to optimize the processing costs and to perform economic evaluation of specific sites. Ulti-

mately, the model can be utilized to establish a priority listing for a region in assisting the determination of reclamation strategy. Research done under grants G1105064, G1115172, and G11195016 by Southern Illinois University. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, and Pittsburgh, PA; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 161-83. A Study of Superconducting Separators for Weakly-Magnetic Ores, by M. K. Abdelsalam, R. W. Boom, and R. R. Hughes. June 1,

1983. 200 pp. 100 figs. A high field helical flow slurry separator was constructed to concentrate weakly magnetic ores with a magnetic moment about the value of hematite. The process is to flow the slurry helically around a current-carrying conductor in a cylindrical annulus. The magnetic field gradient forces magnetic particles inwards while nonmagnetic particles are deflected outwards by centrifugal force. Separation occurs at the exit end of the channel by a divider that separates inboard from outboard slurry. The separator performance was studied both theoretically and experimentally. A universal theoretical model was developed based on turbulent diffusion in cyclones.

The model is in good agreement with experimental data. Research done under grant G0177066 by the University of Wisconsin—Madison. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, and Salt Lake City, UT; Office of Assistant Director—Minerals and Materials Research Bureau of Mines, Washington, DC; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 162(1)-83. Mining in Low Coal. Volume I: Biomechanics and Work Physiology, by M. M. Ayoub,

N. J. Bethea, M. Bobo, C. L. Burford, D. K. Caddel, K. Intaranont, S. Morrissey, and J. L. Selan. November 1981. 175 pp. 69 figs. The objectives of this research were (1) to evaluate the job demands associated with low coal mining; (2) to survey the anthropometry, strength, and aerobic capacity of low coal miners to determine if they differ from the U.S. population; and (3) to recommend, on the basis of available information, optimal job and work station design for low coal mining. The male and female anthropometry, except for weight and circumferential dimensions, was quite similar to the comparison populations. Back strength for male and female miners was significantly lower than the industrial worker population. This can be one of the contributing factors of low back problems in mining. Shoveling, timbering, and helpers tasks were physiologically demanding activities. However, because of the frequent stoppage of work, adequate rest was usually available. If work stoppage is corrected, then better work and rest schedules are essential. Research done under contract H0387022 by Texas Tech University. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy,

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Beckley, WV; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-258160; paper copy price code A08.

OFR 162(2)-83. Mining in Low Coal. Volume II: Anthropometry, by M. M. Ayoub, N. J. Bethea, M. Bobo, C. L. Burford, D. K. Caddel, K. Intaranont, S. Morrissey, and J. L. Selan. Jan. 15, 1982. 123 pp. 54 figs. This report covers the anthropometric study of low coal miners. The male and female anthropometry, except for weight and circumferential dimensions, was quite similar to the comparison populations. The miners tended to be heavier and have greater circumferences. The measurements made in this study were used to develop 5th, 50th, and 95th percentile, quarter- and half-scale, male and female mannequins. The mannequins can be used in workplace and equipment design and redesign. Research done under contract H0387022 by Texas Tech University. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-258178; paper copy price code A06.

OFR 162(3)-83. Mining in Low Coal. Volume III: Clothing Design Study, by D. K. Caddel, J. L. Selan, J. L. Smith, and M. M. Ayoub. Jan. 15, 1982. 75 pp. 48 figs. Several problems exist with the present design of coveralls used by low coal miners. The back of the coveralls often tears when roof bolts or rough areas in the roof are hit. Movement in the shoulder area is restricted. Female low coal miners find it difficult to purchase coveralls that fit properly and must remove both their hard hat and safety belt to urinate and defecate. The objective of this research was to design coveralls that would alleviate these problems. The following features were incorporated into the coveralls: padding in the back, an action pleat in the shoulders, an inseam zipper to more easily allow miners to perform their bodily functions, and reflective tape to increase visibility of the miner. A heavy denim fabric was used to increase warmth and durability. The coveralls were assessed for comfort, safety, worker productivity, and fabric suitability using both an infield assessment by miners and simulation studies. The experimental coveralls proved superior to standard coveralls along all four parameters. Work clothing sizes for female miners were developed. Research done under contract H0387022 by Texas Tech University. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-258186; paper copy price code A05.

OFR 163-83. Proceedings of the Sixth WVU Conference on Coal Mine Electrotechnology, ed. by Wils L. Cooley. July 1982. 428 pp. 170 figs. This report is a compilation of papers presented at the 6th West Virginia University Conference on Coal Mine Electrotechnology in Morgantown, WV, on July 28-30, 1982. The papers cover areas of power systems, communications, safety systems, automation and control, safety devices and instrumentation, and monitoring systems. Report prepared under contract J0123017 by West Virginia University. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-255984; paper copy price code A19.

OFR 164-83. Evaluation of Bulkheads for Radon Control, by Clifford H. Summers, Donald B. Lindsay, Richard S. Lindstrom, and Kenneth L. Alder. July 1982. 88 pp. 19 figs. The objective of this task was to investigate the availability and suitability of some novel materials and methods of construction for air-restraining bulkheads for use in confining radon-rich air in unused sections of underground uranium mines. Two preferred systems of bulkhead construction were proposed, based on a search of commercially available materials, and were successfully tested in an operating commercial mine in LaSal, UT. Both systems were found to be generally satisfactory under the conditions of the 5-month-long test. As an auxiliary aid to prevent leakage of radon-polluted air from the bulkhead area, a servocontrolled exhaust system was designed to maintain a favorable atmospheric-pressure gradient relative to the rest of the mine. A radon-scavenging system, based on adsorption on activated charcoal, was also designed and successfully tested for use in connection with the pressure-balancing exhaust unit. Research done under contract H0212003 by Arthur D. Little, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-256503; paper copy price code A05.

OFR 165-83. Development of a Nondestructive Test Device for Friction Rock Supports, by R. Lusignea, J. Felleman, and K. Kirby. February 1983. 135 pp. 58 figs. A device was developed for non-destructive testing of the holding power of split-tube friction rock supports. The device operates by measuring the amount of decrease in internal volume when the support is forced into the drilled hole. The pullout force, or slip load, is a function of the decrease in volume. The device gives readouts of the average internal diameter and predicted pullout force for the support. Laboratory and field tests showed excellent repeatability and good correlation between predicted and actual pullout force. The device is hand-operated, lightweight, and can

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be used on any friction support. Research done under contract H0202030 by Foster-Miller, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-257519; paper copy price code A07.

OFR 166-83. Assessment of Alternative Power Sources for Mobile Mining Machinery, by James E. Cair-

elli, William A. Tomazic, David G. Evans, and John L. Klann. December 1981. 109 pp. 60 figs. The National Aeronautics and Space Administration Lewis Research Center, under an agreement with the Bureau of Mines, performed an assessment of alternative power sources for mining applications, primarily mobile underground equipment. Each alternative power source was assessed in terms of (1) ability to achieve the duty cycle, (2) ability to meet Government regulations, (3) production readiness, (4) market availability, and (5) packaging capability, which were established as a first step in the assessment. An initial screening reduced possible alternative power sources, that were evaluated in more detail, to (1) improved diesel, (2) Stirling, (3) gas turbine, (4) Rankine, (5) advanced electric, (6) mechanical energy storage, and (7) use of hydrogen evolved from metal hydrides. The alternative power sources were divided into two categories, heat engines and energy storage systems, because heat engines are basically limited by emissions and energy storage systems are limited by energy storage density. Each alternative power source is described briefly, including its current development status, specific problem areas, and possible future improvements. Each is then evaluated against the requirements initially established. Research and development efforts for each alternative power source are discussed and evaluated in terms of potential. Research done under contract J0100026. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: N83-14691; paper copy price code A06.

OFR 167-83. Field Demonstration of Deep-Penetrating Geophysical Techniques, by S. A. Suhler and

T. E. Owen. January 1983. 68 pp. 27 figs. Field tests were conducted to demonstrate the performance of an advanced development model borehole directional radar probe in coal measure rocks. Preliminary test site evaluations at five candidate coal mines were performed to determine the electromagnetic propagation parameters of the coal seams and to inspect available geologic mine hazards such as paleochannel sand cutouts, faults, and weak roof conditions as potential radar test targets. The York Canyon Mine near Raton, NM, was selected as the demonstration site. Surface-operated tests in vertical boreholes as well as in-mine tests in horizontal boreholes were conducted using the radar probe, resulting in the detection of a near-vertical seam displacing fault. Other electromagnetic tests using separate source and receiving probes in vertical

boreholes as well as in through-transmission tests in underground coal pillars provided useful data on the electromagnetic parameters of the coal and large-scale geologic structures. One series of transmission tests was successful in coupling across the fault-displaced coal seam. All of the tests utilized pulsed electromagnetic signals in the 30- to 300-frequency range. Research done under contract H0212018 by the Southwest Research Institute. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; U.S. Department of Energy, Pittsburgh, PA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-256222; paper copy price code A04.

OFR 168-83. Recommended Acceptance Criteria for Potting Materials Used in Explosion Proof Enclosures

in Coal Mines, by W. R. Herrera, R. E. White, L. M. Adams, and H. S. Silvus. March 1982. 100 pp. 17 figs. Research was conducted to develop methodology for evaluating candidate potting materials intended for use in explosion-proof enclosures. The primary purpose was to develop acceptance guidelines based on arc decomposition products. Acceptance criteria can be based on (1) inherent thermochemical, mechanical, and electrical properties; (2) arc decomposition products (nature of volatile products produced; e.g., flammability, explosivity, synergistic effects on existing environment in the enclosure, and toxicity; and quantity produced as a function of arc power and duration); and (3) acceleration aging tests to evaluate breakdown under electrical stress. Research done under contract J0100041 by the Southwest Research Institute. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-254722; paper copy price code A05.

OFR 169-83. Low Glare Luminaire for Thin Seam Mining,

by John R. Parker and William F. Hahn. October 1982. 102 pp. 42 figs. Work places of an underground coal mine are required (30 CFR 1719) to be illuminated while self-propelled equipment is used. Permissible machine-mounted systems have been developed and applied satisfactorily to many mining operations. However, some low- and thin-seam equipment has been difficult to illuminate because reliable, direct current (dc) systems and compact, low output, low-glare luminaires were not available. This program resulted in the design and prototype construction of compact, low-glare luminaires and alternate current (ac) power systems, particularly suited to resolving illumination problems on low- and thin-

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seam mining equipment. Design objectives were based on enhancing the prospects for thin-seam illumination solutions through definition of a product that could challenge markets enjoyed by higher glare luminaires and through reduction of technical risks associated with any new product development as well as the MSHA certification process. Research done under contract J0188077 by Booz, Allen & Hamilton, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-257246; paper copy price code A06.

OFR 170-83. Cost-Effectiveness of Increasing Airflow at Any Location in Underground Coal Mines (Volume I), by Sandip K. Mukherjee, Anthony W. Laurito, M. O. Rahim, and Madan M. Singh. February 1983. 113 pp. 16 figs. This report presents the results of the economic analyses of several applicable alternatives to increase airflow in four underground coal mines. Pressure and quantity surveys were conducted underground, and measurements were made at the main mine fans. The existing ventilation networks were modeled using a modified ventilation simulator, and the applicable alternatives were simulated. Performance data obtained from the simulation runs were utilized to conduct the cost-effectiveness analyses. The costs for each of the alternatives included capital, operating, and maintenance. These costs were expressed as annual ventilation costs per active section in terms of dollars per cubic foot per minute, taking into account the economic life associated with each of the alternatives. The benefits were expressed as increased airflow quantity in the critical sections. A section of the report also deals with comparison of simulator-predicted air quantity values against air quantity values measured underground. Research done under contract J0100066 by Engineers International, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-257105; paper copy price code A06.

OFR 171-83. Noise Reduction of Chain Conveyors. Volume II, by A. Galaitis, R. Madden, and D. Andersen. February 1983. 63 pp. 26 figs. This report briefly reviews the aboveground tests performed on a Jeffrey 120M conveyor that were documented in volume I of this study, and describes the performance of treatments implemented on underground equipment. The noise level at the operator's position in the aboveground test facility was reduced from 101.5 to 91 dBA using treatments with satisfactory aboveground durability. Extensive underground evaluation was performed only on the

constrained layer damping, which has reduced the conveyor noise by 2 to 6 dBA, depending upon the operating conditions, and was shown to be sufficiently durable. Other promising candidates for exploratory evaluation include resilient layers for the top and bottom decks and smoother discontinuities between adjacent conveyor sections. Research done under contract H0155113 by Bolt Beranek and Newman Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-262634; paper copy price code A04.

OFR 172-83. Theoretical Study, Design and Analysis of an Improved Shuttle Car Cable Reel, by P. W. Meisel and G. J. Hundman. August 1983. 70 pp. 42 figs. A hydraulic-powered reel system to minimize peak tension transients in shuttle car trailing cables was theoretically designed and analyzed using a computer. A single, spring-loaded takeup sheave stores or gives up cable to maintain tension within specified limits. Controls were incorporated to shut down the vehicle before all cable is removed from the reel and to deenergize the cable in the event of a reel-cable jam. Full-scale hardware configuration drawings sufficient for manufacture of a test system were completed. Research done under contract J0318086 by Jeffrey Mining Machinery Div., Dresser Industries, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-262352; paper copy price code A04.

OFR 173-83. Instruments and Techniques for Dynamic Particle Size Measurement of Coal Dust, by Virgil A. Marple and Kenneth L. Rubow. January 1981. 242 pp. 122 figs. The purpose of this study was to conduct research in several areas of instrumentation used to determine the quantity of respirable dust in a mining atmosphere. The study was divided into eight tasks including (1) the feasibility of using a dichotomous impactor in conjunction with two photometers for a machine-mounted dust monitor, (2) development of a laser diode optical particle counter, (3) development of an instrument evaluation chamber, (4) instrument evaluations and calibrations, (5) development of a new personal respirable dust sampler, (6) development of a uniform deposit cascade impactor, (7) inertial impactor calibrations and theoretical investigations, and (8) descriptions of field studies. Research done under contract H0177026 by the University of Minnesota. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and

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Safety Academy, Beckley, WV; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-262360; paper copy price code A15.

OFR 174-83. Safety Evaluation of Conveyor Belt Cleaning Systems, by William Kleysteuber. Jan. 14, 1983. 118 pp. 88 figs. The focus of this study was to determine the effectiveness of practical conveyor belt cleaning devices in removing the material that carries back past the normal discharge point from the return strand belt so that it can not fall off. The material that falls off becomes part of the spillage that requires manual cleanup and increases miner exposure to hazards. The belt-cleaning problem was found to be much more complex than simply the removal of this material. The material becomes spillage by an interaction of the belt with the return roller that is governed by the characteristics of the carry-back material and is dependent upon moisture content and particle size distribution. The results of laboratory tests show that practically any type of blade held in intimate contact with the belting will reduce the amount of material carried back. Effective cleaning, however, requires high pressure on a blade material compatible with the carried back material in that it is not cut and grooved by the particles. Selection of cleaning methods is largely controlled by site-specific conditions at the installations and the end use of the product. This report defines engineering criteria that will increase the effectiveness of belt cleaning devices and methods and suggests a method to predict the costs of cleaning. Research done under contract J0215015 by Wyle Laboratories. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-262592; paper copy price code A06.

OFR 175-83. Fire Hazard Criteria for Noise Control Products in Underground Coal Mines, by Mark R. Pettitt, R. E. Giuntini, and William R. Wessels. May 1983. 211 pp. 61 figs. The development of fire hazard criteria for noise control products in underground coal mines are presented. Qualifying requisites of the criteria include maintaining miners' safety, allowing for maximum use of noise control products, and economic feasibility. The burning process is analyzed for its relationship to fire hazard criteria developed by the National Aeronautics and Space Administration and the Federal Aviation Administration, and the mine environment is analyzed in conjunction with the end-use applications of noise control products. Also, the interim fire hazard specification developed by the Mine Safety and Health Administration is appraised as it applies to end-use applications of noise control products. From these analyses and a literature survey, fire hazard criteria are developed that include an initial screening procedure that evaluates the level of flammability testing required. Research done under contract J0395100 by Wyle Laboratories. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD,

Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-262584; paper copy price code A10.

OFR 176-83. Design and Demonstration for Area Walkway Lighting on Electric-Powered, Mobile, Surface Mining Equipment, by Martin H. Wahl. Nov. 1, 1982. 119 pp. 46 figs. The January 13, 1977, Federal Register (v. 42, No. 9, sec. 77.027, par. d) proposed new regulations specifically applicable to above-ground operations directly related to illumination of areas in, on, and around draglines, shovels, and wheel excavators. This report details the design, installation, and demonstration of lighting systems of large draglines and shovels for areas 20 ft in all directions from the main frame, exterior walkways on board the mining machines, and the area beneath the boom 20 ft from the main frame to the farthest point the equipment is capable of excavating or discharging materials. Research done under contract H0387024 by the Mine Safety Appliances Co. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 83-262600; paper copy price code A06.

OFR 177(1)-83. Electrical-Shock Prevention. Volume I—Protection of Maintenance Personnel, by L. A. Morley, T. Novak, and F. C. Trutt. Dec. 8, 1982. 127 pp. 61 figs. The objective of this four-volume report was to investigate the application, economic, and safety considerations of electrical-shock prevention techniques applied to surface and underground mines. This report is primarily concerned with the protection of maintenance personnel. The scope of the work is specified, electrical shock is defined, and needed ground-fault relay characteristics to prevent ventricular fibrillation are established. This is followed by an analysis of ac systems, a comparison of these systems with respect to body currents, the advantages and disadvantages of the various ground-fault protection techniques, and an analysis of dc systems for off-track vehicles. Summaries and synopses of each of the three remaining volumes are included. Research done under contract J0113009 by the Pennsylvania State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Assistant Director—Mining Research, Bureau of Mines, and

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the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84-102946; paper copy price code A07.

OFR 177(2)-83. Electrical-Shock Prevention. Volume II—Ground-Fault Interrupting Devices, by L. A. Morley, F. C. Trutt, and D. J. Rufft. Dec. 8, 1982. 110 pp. 60 figs. This report is primarily concerned with the application of sensitive ground-fault interrupters (GFI's) to ac utilization circuits in U.S. mines. The main concepts examined are shock prevention and methods to reduce nuisance tripping. The research involved a literature search, input from previous Bureau of Mines contracts, and contacts with electrical manufacturers and mining personnel. Several devices that showed promise were tested and the results indicate the existence of GFI's that may be modified to perform adequately on U.S. mining systems. A set of guidelines covering design, construction specifications, and performance tests is included. Research done under contract J0113009 by the Pennsylvania State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Assistant Director—Mining Research, Bureau of Mines, and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84-102953; paper copy price code A06.

OFR 177(3)-83. Electrical-Shock Prevention. Volume III—Fault Protection for Motion-Drive Equipment, by L. A. Morley, F. C. Trutt, and G. M. Buchan. Dec. 8, 1982. 65 pp. 17 figs. This report examines the indication versus interruption procedures used on motion-drive power equipment with emphasis on surface excavators. A review of the electromechanical ac-dc conversion used with the control system is presented. Protection for the drive-system components are discussed. Fault sources and calculations for both the ac supply source and dc power loop are introduced to assist in discussing indication and interruption procedures. The dynamic process of the machine is examined and the effects of fault current and position of the machine to allow for an orderly shutdown is determined. Possible indication and interruption procedures are given for the four-quadrant duty cycle of excavators. The report is concluded by introducing other mining operations that utilize similar motion-drive systems and static (solid-state) drives and recommends further research in these areas, as well as a more detailed examination of the dynamic fault analysis for excavators. Research done under contract J0113009 by the Pennsylvania State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Assistant Director—Mining Research, Bureau of Mines, and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84-102961; paper copy price code A04.

OFR 177(4)-83. Electrical-Shock Prevention. Volume IV—Overhead-Line Contact Fatalities, by L. A. Morley, F. C. Trutt, and G. T. Homce. Dec. 8,

1982. 116 pp. 35 figs. This report examines the problem of indirect contact of overhead high-voltage powerlines by mining personnel. This refers to the contact of energized lines by workers through an intermediate conductor such as a metallic tool or a piece of high-reaching mobile equipment. The shock hazard by such contact has been a major cause of electrical fatalities associated with mining operations. The report is divided into three areas. The first gives a general background of overhead lines, basic characteristics, and associated hazards and describes presently used techniques and devices that attempt to alleviate the contact problem. The second area presents a detailed analysis of 39 overhead-line contact accidents in mining since 1970. The third section used the information in the first two areas to formulate recommendations to prevent these accidents and subsequent electrocutions at mining installations. Research done under contract J0113009 by the Pennsylvania State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Assistant Director—Mining Research, Bureau of Mines, and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84-102979; paper copy price code A06.

OFR 178-83. Compressed Oxygen One-Hour Self-Rescuer, by Michael A. Borrello. January 1983. 49 pp. 18 figs. A 60-min-duration, compressed-oxygen self-rescuer for emergency escape from coal mines was developed. The design, a closed-circuit pendulum-type rebreather, contains special techniques in packaging, cooling, gas flow, and human engineering factors. Test results on the performance of the apparatus are presented and recommendations are made for further improvement of the design. Research done under contract J0100074 by U.S.D. Corp., Survivair Div. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84-105337; paper copy price code A03.

OFR 179-83. Analysis of Electrical Accident Prevention Countermeasures, by W. L. Cooley, W. Collins, Z. Elrazar, R. Kumar, R. McConnell, and M. Jerabek. Dec. 31, 1982. 359 pp. 84 figs. This report provides a detailed analysis of 23 electrical accident countermeasures contemplated for use in the metal-nonmetal mining industry. The costs and potential benefits of implementing groups of countermeasures are estimated, and methods are outlined by which countermeasures can be selected in an effective manner. The analysis is based largely on an extensive electrical accident event tree that is developed in detail. For those countermeasures that are not currently technically feasible, several prototype devices were developed to help speed development. Research done under contract J0113064 by the West Virginia University. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN,

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Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Assistant Director—Mining Research, Bureau of Mines, and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84-102987; paper copy price code A16.

OFR 180-83. Modeling of Solution Mining Systems for Deep Mineral Resources Recovery, by Milton E.

Wadsworth and H. Y. Sohn. May 1983. 110 pp. 32 figs. Laboratory studies were carried out to identify and quantify the important processes operative in solution mining of minerals. Specifically, the kinetics of leaching copper from chalcopyrite-bearing ore particles were determined under various oxygen partial pressures and temperatures. The effect of particle size on the rate of leaching was also investigated. Computer simulation models to predict the copper recovery from an underground rubblized ore body were developed. One model describes the process in which oxygen-saturated leach solution is used with no bubbles in the bed. The other model is applicable when leach solution containing oxygen bubbles is used for leaching. Research done under grants G1105088, G1115494, and G1195047 by the University of Utah. Available for reference at Bureau of Mines facilities in Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, and Salt Lake City, UT; Office of Assistant Director—Mineral and Materials Research and Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84-103837; paper copy price code A06.

OFR 181-83. Simplex Gasification Demonstration in the Wellman-Galusha Gasifier, by the Mining

and Industrial Fuel Gas Group, the U.S. Bureau of Mines, and Dynecology, Inc. June 30, 1982. 110 pp. 40 figs. The objectives of this project were to produce at least 200 tons of simplex briquets and to evaluate their performance as a fixed-bed, dry-bottom gasifier feedstock. To accomplish this, 240 tons of caking coal and shredded municipal refuse were compacted into simplex briquets and gasified in a Wellman-Galusha producer at the Bureau of Mines in Minneapolis, MN. It was concluded that the briquets have good potential as a gasifier feedstock and that the briquets do not swell or cake even though they contain 67 wt pct of a highly caking eastern bituminous coal. Research done under contract J0205070. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Avondale, MD, Twin Cities, MN, Reno, NV, Albany, OR, and Salt Lake City, UT; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84-103324; paper copy price code A06.

OFR 182-83. Leaching of Uranium and Fluorine From Quenched Slag, by C. M. Wai and K. A.

Prisbrey. Jan. 15, 1982. 28 pp. 17 figs. Waste slag from the Phosphoria Phosphate Formation in Utah, Idaho, and Montana contains one of the Nation's largest reserves of uranium. Large quantities of phosphate slag was premixed in pretreatments and fluorite from before solidifying. By appropriate pretreatment, it was anticipated to stimulate selective leaching of valuable constituents at low acid consumption. In this project, the mechanisms of leaching were identified by analysis of leaching

kinetics. The change in mechanisms associated with slag pretreatments were identified and quantified in terms of mass transfer, solid-state diffusion, and chemical reaction rates. A kinetic leaching model was used to predict treatments that were potentially economical. Although this research did not show that the economics of dilute acid leaching are favorable, it does point toward some innovations. Research done under grant G5105020 by the University of Idaho. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Avondale, MD, Reno, NV, Albany, OR, and Salt Lake City, UT; and Office of Assistant Director—Mineral and Materials Research, Bureau of Mines, and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 183-83. Combined Stability-Deformation Analysis for Rock Slopes in Open Pit and Strip Mines,

by John Kafritsas, Herbert H. Einstein, and Gregory B. Baecher. September 1983. 115 pp. 23 figs. This report presents a computer analysis that couples the deformation of a rock mass and the flow of water in its joints. Two-dimensional problems involving a rock mass transversely by relatively closely spaced joint sets that divide it into distinct blocks can be treated. Deformations are modeled using the rigid block method, which assumes that the rock mass is composed of rigid rocks with the deformable contact points. The analysis proceeds in time steps, evaluating at a series of successive instants the forces acting on each block. The forces are used to find the acceleration of each block, which is then integrated to find the displacement increment of each block during the time step under consideration. There are considerably different force-deformation laws, time-dependent behavior, or expansive properties of joint fillers. Flow is modeled by recognizing its discontinuous features as occurring in a system of interconnected conduits formed by the joints. Both laminar and nonlaminar flow can be modeled, as can problems involving free-surface flow. Full account is taken of the coupling between flow and deformation. Water forces are continuously updated to account for changing joint and apertures caused by block displacements, and vice versa, and block displacements between time steps take into account the changing water-pressure field. Research done under grants G1105027 and G1115251 by the Massachusetts Institute of Technology. Available for reference at Bureau of Mines facilities in Denver, CO, Avondale, MD, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 184-83. Solids Flow in a Recirculating Fluidized Bed, by Takafumi Matsuzaki and John F.

Elliott. June 1983. 115 pp. 59 figs. The objective of this study was to evaluate the general nature of solids flow in a 30-cm-ID recirculating fluidized bed using silica sand. A bubbling or turbulent bed with a density of $\frac{1}{2}\rho_b$ was observed in the lower part of the reaction and a pneumatic transport phase with a density of $\frac{1}{100}\rho_b$ was observed in the upper part. The solids feed rate was regulated by a nonmechanical valve called an "L-valve." The

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maximum solids feed rate through the L-valve is limited by the head of solids in the downcomer. The saturated solids carryover rate was found to be proportional to the fourth power of the gas velocity. Recommendations for further studies and modifications to the system are presented. Research done under grant G1115252 by the Massachusetts Institute of Technology. Available for reference at Bureau of Mines facilities in Avondale, MD, and Albany, OR; Office of Assistant Director—Mineral and Materials Research, Bureau of Mines, and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 185-83. Iowa Coal Project Demonstration Mine, Oskaloosa, Iowa, by Iowa State University. May 1981. 35 pp. 5 figs. This 37-acre tract was leased by Iowa State University in 1975 and is located 8½ miles southwest of Oskaloosa. Reclamation was completed in November 1977, after 108,000 tons of coal was mined at the site. The present research deals with the post-restoration management of reconstructed soil and the environmental quality of reclaimed land. Research done under grant G1105024. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Office of Assistant Director—Mining Research, Bureau of Mines, Washington, DC; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 186(1)-83. Development of a Continuous Shaft Lining System, Volume I, by Robert Torbin, Tom Brunsing, Douglas Ounanian, Ray Henderson, Jonathan Kelly, and George Kirby. May 1983. 224 pp. 72 figs. The objective of this three-volume report was to develop a system to reduce the costs, safety hazards, and time currently required in lining mine shafts with concrete. The continuous shaft lining (CSL) system will line machine-bored shafts downward from the shaft collar on a continuous basis using an inverted, pressurized slipforming technique. Volume I describes the basic CSL concept, the design and operation of a prototype unit, and estimates of cost. Research done under contract J0333915 by Foster-Miller, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS; PB 84-113216; paper copy price code A10.

OFR 186(2)-83. Development of a Continuous Shaft Lining System, Volume II, by Robert Torbin, Tom Brunsing, Douglas Ounanian, Ray Henderson, Jonathan Kelly, and George Kirby. May 1983. 120 pp. 42 figs. The objective of this three-volume report was to develop a system to reduce the costs, safety hazards, and time currently required in lining mine shafts with concrete. The continuous shaft lining system will line machine-bored shafts downward from the shaft collar on a continuous basis using an inverted, pressurized slipforming technique. Volume II summarizes the results of the laboratory- and full-scale tests conducted during the program. Research done under contract J0333915

by Foster-Miller, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84-113224; paper copy price code A06.

OFR 186(3)-83. Development of a Continuous Shaft Lining System, Volume III, by Robert Torbin, Tom Brunsing, Douglas Ounanian, Ray Henderson, Jonathan Kelly, and George Kirby. May 1983. 510 pp. 79 figs. The objective of this three-volume report was to develop a system to reduce the costs, safety hazards, and time currently required in lining mine shafts with concrete. The continuous shaft lining system will line machine-bored shafts downward from the shaft collar on a continuous basis using an inverted, pressurized slipforming technique. Volume III, the appendix, contains related information on the laboratory tests and test facilities. Research done under contract J0333915 by Foster-Miller, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84-113232; paper copy price code A22.

OFR 187-83. The Impact of Longwall Mining on the Hydrologic Balance; Premining Data Collection, by Ginger S. Evans, Tsegaye Hailu, Helen M. Weagraff, James W. Warner, and G. Steve Lowry. May 31, 1983. 141 pp. 34 figs. This report documents a preliminary hydrologic investigation of an area where longwall mining methods are to be used. The scope of work includes determination of physical and chemical characteristics of major soil types in the area; determination of physical and chemical properties of surface water bodies; collection of geologic characteristics, including stratigraphy, structure, and detailed aquifer descriptions; a 10-year collection of meteorological data and installation of a weather station; and a detailed ground water investigation that includes completion of observation wells, aquifer testing, water quality sampling, and analysis using a 3-D computer model. The Trescott model developed by the U.S. Geological Survey was used to simulate steady-state aquifer conditions. Input data from eight multiple-completion monitor wells were used to model an area of approximately 10 square miles. Two confined layers, coal and overburden, were simulated. Model results showed good agreement with known piezometric data, desaturated areas, and flow from springs. Research done under contract J0218025 by J. F. Sato and Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84-113174; paper copy price code A07.

OFR 188-83. Survey of Blasting Effects on Ground Water Supplies in Appalachia. Part II, by Philip R.

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Berger, D. T. Froedge, James A. Gould, and Lorraine F. Kreps. August 1982. 114 pp. 25 figs. This report covers an 18-month study of the performance of a 300-ft-deep test water well located at the Ayrshire Mine of the AMAX Coal Co. near Evansville, IN. Well performance, as characterized by 10-hr drawdown tests, was monitored as the strip mining operation approached the well site from distances of 2,000 to 15 ft (overburden removal). Blast-induced ground motion was measured at the surface next to the test well, and peak particle velocities in excess of 4 in/s were obtained. No evidence of changes in water quantity or quality could be directly attributed to the blasts. However, some lowering of the static water level in the observation well, and a simultaneous increase in the adjusted specific capacity of the test well, suggest that overburden removal caused lateral stress relief with consequent opening of vertical fractures. Research done under contract J0285029 by Philip R. Berger and Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84-113182; paper copy price code A06.

OFR 189-83. Stable Isotope Variations in Coals and Associated Mineral Matter, by Thomas F. Anderson. August 1983. 79 pp. 18 figs. Measurements of stable isotopic variations (sulfur, carbon, and oxygen), supplemented by chemical, mineralogical, and petrographic analyses, were used to investigate the processes responsible for the incorporation of sulfur in coal and the development of permineralized peat zones (coal balls). Sulfur isotopic results indicate that there are two principal sources in Pennsylvania coals from the Illinois Basin: (1) primary sulfur assimilated by plants (low-sulfur coal), and (2) secondary sulfur produced by reactions involving H_2S that was produced by the anaerobic reduction of sulfate in seawater that permeated the peat during postdepositional marine transgressions (the dominant source of sulfur in high-sulfur coals). Sulfur isotopic compositions of low-sulfur coals in several Tertiary basins of Wyoming are consistent with a plant sulfur source. However, the inverse correlation between content and isotopic composition of sulfur observed in coals from the Powder River Basin suggest some secondary additions to these low-sulfur coals. Several Quaternary freshwater peats that were submerged by sea level rises during deglaciation have sulfur contents and isotopic compositions similar to high-sulfur coals. Carbon and oxygen isotopic compositions of calcareous coal balls from North America and Europe suggest that the carbonate was derived from variable proportions of oxidized plant matter and inorganic carbonate, and the carbonate minerals were precipitated from fresh-to-brackish waters. Local geochemical and hydrological conditions were apparently more important than regional depositional environments in controlling the source of carbonate and the development of coal balls. Research done under grant G1115171 by the Southern Illinois University at Carbondale. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Office of Assistant Director—Mining Research, Bureau of Mines,

and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 190-83. Iowa Coal Project Demonstration Mine, Oskaloosa, Iowa. Annual Progress Report—1982, by Stan Henning, R. B. Hall, G. A. Miller, M. L. Thompson, C. R. Klein, R. C. Schultz, and H. M. Van Es. May 1983. 50 pp. 12 figs. This 37-acre tract was leased by Iowa State University in 1975 and is located $8\frac{1}{2}$ miles southwest of Oskaloosa. After 108,000 tons of coal were mined at the site, reclamation was completed in November 1977. The present research deals with the postrestoration management of reconstructed soil and the environmental quality of reclaimed land. Research done under grants G1105024 and G1115191 by the Iowa State University. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Office of Assistant Director—Mining Research, Bureau of Mines, and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 191-83. Mining Resources and Potential Problems Associated With Mining of Cenozoic Rocks of the Williston and Powder River Basins, Northern Great Plains, by Richard D. LeFever and Edward C. Murphy. September 1983. 174 pp. 73 figs. The objective of this study was the compilation and assessment of existing data on mining resources and potential problems associated with mining of Cenozoic rocks in the Williston and Powder River Basins in the Northern Great Plains. The report presents an interpretation of the three-dimensional stratigraphic framework and depositional setting of the Cenozoic sedimentary section, and the construction of a data base accessible to scientists and other users. The bibliography consists of about 800 references on sedimentology, stratigraphy, coal and uranium reserves, coal chemistry, ground water and rock geochemistry, and rock mineralogy. The references are cross-indexed by subject matter and geographic location. The computer data base contains data from 8,508 locations and has about 12,500 entries in the various individual data sets. Research done under grants G1105042 and G1115381 by the University of North Dakota. Available for reference at the Bureau of Mines Avondale (MD) Research Center; Office of Assistant Director—Mineral Data Analysis and Office of Technical Information, Bureau of Mines, and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 192-83. Characterization of Subsidence Over Longwall Mining Panels—Eastern Coal Province, by Peter J. Conroy and Julianne H. Gyarmaty. May 1983. 120 pp. 53 figs. The objective of this study was to describe the physical response of overlying strata to longwall mining of panels and observe changes in surface and ground water flows caused by subsidence from underground mining. The study was performed at Quarto Mining Co.'s No. 4 mine in the eastern coal province. The work included monitoring both surface and underground instrumentation and characterizes surface subsidence and strain, determines the potential effects of subsidence on cultural features including structures and water supplies, and develops criteria to assist in predicting

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subsidence for mines with similar mining and geologic conditions. Research done under contract J0133920 by Dames & Moore. Available for reference at the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 193-83. Testing and Demonstration of Roof Bolter Instrumentation for Detecting Hazardous Roof, by Richard Lusignea and John Felleman. April 1983. 165 pp. 34 figs. A single-boom roof bolting machine was outfitted with measurement and recording systems to detect changes in machine parameters while drilling. The purpose of the instrumented bolter was to detect changes in roof conditions from the machine parameters of penetration rate, thrust, rotation rate, torque, reflected light from rock cuttings, and vibration of the roof during drilling. The system was demonstrated underground in coal mine conditions and showed correlation between rock type and drilling parameters. Research done under contract H0202008 by Foster-Miller, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 194-83. Dry Dust Collector, by Gary R. Gillingham and Jon P. Sandstedt. March 1982. 121 pp. 57 figs. The objective of this investigation was to design, fabricate, and demonstrate a small, safe, simple, and rugged dry dust collector suitable for face (including machine mounting), belt transfer, and other mining applications. The report traces the development of the dry dust collector from the original design concept and component testing performed during phase I to the fabrication, laboratory testing, and field evaluation of two mine-worthy dry dust collector prototypes during phase II. Successful field evaluations took place at a belt transfer point in a trona mine and a bagging station at a silica sand plant. Future modifications suggested by the field evaluations as well as production cost estimates are included in the report. Research done under contract H0395039 by Donaldson Co., Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; and Office of Assistant Director—Mining Research, Bureau of Mines, and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84-127356; paper copy price code A06.

OFR 195(1)-83. Evaluation of Safety Assessment Methods for the Mining Industry. Volume I, by P. M. Daling and C. A. Geffen. May 1983. 123 pp. 19 figs. The objectives of this study were to examine a representative cross section of formal safety analysis techniques developed for the nuclear and aerospace industries, to recommend those methods that would be suitable for application to the mining industry, and to include those methods in a user's

manual. Volume I of this two-volume report presents the results of the examination of available safety assessment methods. The major safety concerns and needs of mine operators were identified through telephone contacts and a visit to a minesite. Safety assessment methods recommended for use by the mining industry were also investigated for potential adaptability to a user-interactive computer system. Several methods were determined to be immediately transferrable to the mining industry and are described in Volume II. Research done under contract J0225005 by Battelle, Pacific Northwest Laboratories. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Assistant Director—Mining Research, Bureau of Mines, and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84-126440; paper copy price code A06.

OFR 195(2)-83. Evaluation of Safety Assessment Methods for the Mining Industry. Volume II. User's Manual of Safety Assessment Methods for Mine Safety Officials, by P. M. Daling and C. A. Geffen. May 1983. 96 pp. 15 figs. The objectives of this study were to examine a representative cross section of formal safety analysis techniques developed for the nuclear and aerospace industries, to recommend those methods that would be suitable for application to the mining industry, and to include those methods in a user's manual. The user's manual, this report, describes several methods that were determined to be immediately transferrable to the mining industry. The manual gives detailed instructions on appropriate application and utilization of the methods. Research done under contract J0225005 by Battelle, Pacific Northwest Laboratories. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Assistant Director—Mining Research, Bureau of Mines, and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84-126457; paper copy price code A05.

OFR 196-83. Shearer Mounted Dust Collector. Laboratory Testing, by J. Kelly, T. Muldoon, and W. Schroeder. October 1982. 168 pp. 69 figs. Effective control of respirable dust is one of the most serious problems associated with longwall mining in the United States. This report describes the development and laboratory testing of dust collectors for use on double-drum shearers. The systems tested included a high-capacity flooded-bed scrubber and water-powered extraction cowls, extraction drums, and spot scrubbers. The systems were tested using tracer gas in a full-scale model of a longwall shearer face. A detailed description of the test facility, test methods, and system test results is provided. Research done under contract J0387222 by Foster-Miller, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla,

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MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84-126614; paper copy price code A09.

OFR 197-83. In-Situ Shear Strength Tester for Coal, by

Richard L. Handy, Lawrence E. Engle, and John M. Pitt. May 10, 1976. 125 pp. 42 figs. The objective of this research was to develop a lightweight, portable device for rapid in situ measurement of rock shearing strength and to compare the results with those obtained by other test methods. The rock borehole shear test (RBST) operates by expansion of two opposed steel plates against rock in the periphery of a 76-mm (13-in) diameter borehole, followed by axial movement of the plates. Small teeth on the contact plates cause shearing to occur with the rock itself. Several tests were conducted at different applied expansion pressures to generate a failure envelope of shearing strength versus applied normal stress. The envelope is plotted while the test is being conducted; a complete envelope may be generated by four tests in about 45 min. The slope of the envelope is the angle of internal friction, and the extrapolated shearing strength at zero normal stress is the cohesion. Analogous data are obtained for the residual shear strength, or strength along the induced fractures. The device also indicates whether dilatancy, or rock volume expansion, occurs during shearing. Comparative RBST versus triaxial and other tests indicate close agreement of friction angles but somewhat lower cohesions caused by disturbance by the shear plate teeth. Research done under grant G0144021 by Iowa State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84-126481; paper copy price code A06.

OFR 198-83. Foreign Literature on Environmental and Personal Factors Affecting the Safety and Productivity of Miners: A Topical Listing and Annotated Bibliography of Recent Research, by Robert H. Peters. Jan. 4, 1983. 91 pp. 4 figs.

This report is a review of foreign literature concerning human factors issues in the mining industry and updates Bureau of Mines OFR 27-72. About 500 references were located using computerized literature research systems. The references were sorted by topic into six major categories including accident and safety, individual miner, health and medicine, technical and engineering, environment, and ergonomics. Some of the major issues include effects of environmental stress on health and productivity, accident prevention, protective clothing and equipment, miner-machine relationship, training programs, and psychological principles applied to mine problems. Summaries are included for publications that describe the results of empirical investigations of factors affecting miner safety or productivity. It is concluded that foreign countries are improving the safety and productivity of mining operations through (1) improvements in

technologies associated with mining processes; (2) improvements in equipment design; (3) improved understanding of miner physiological, anatomical, and psychological limitations; and (4) implementation of more sophisticated technical devices to monitor and control the underground environment. Research done by the Bureau of Mines Industrial Safety and Training Systems. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84-127687; paper copy price code A05.

OFR 199-83. Determination of Velocity Measurement Correction Factors and Guidelines, by J. L. Kohler and L. M. English. June 1983. 216 pp. 97 figs.

The objective of this study was to establish a set of guidelines to select locations for and applying correction factors to vane anemometer, smoke, and tracer gas velocity measurements. A literature search and analysis was performed, in-mine experiments were conducted, and a quantitative analysis of the data was used to develop correction factor tables and site selection guidelines. The report also presents guidelines to select velocity measurement locations and discusses how to improve cross-section measurements. Research done under contract J0308027 by Ketron, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84-127851; paper copy price code A10.

OFR 200-83. Floodplain Landfill With Mill Tailings, by K. E.

Robinson and H. M. Eivemark. July 1983. 206 pp. 99 figs. This study develops a valley-wide mill tailings disposal plan to utilize 20 potential landfill sites on floodplain areas in the Coeur d'Alene mining district in Idaho, and presents measures to reclaim the sites for subsequent productive use. Field and laboratory testing on one test section and two abandoned impoundments support the use of hydraulically deposited tailings for landfill construction. Hydrological testing showed that controlled discharge from tailings impoundments results in contaminant levels in the discharge below regulated standards. Additional testing indicated that compacted soil liners and pond management provide adequate contaminant abatement where acid-generating tailings are encountered. Mechanical compaction, including surcharge loading, upgrades foundation support capacity so that construction on the surface of tailings deposits is feasible. Details concerning potential landfill sites were refined. At recent production rates, the 20 sites would result in 680 acres of reclaimed land while providing a minimum of 40 years of tailings storage capacity. Research done under contract J0113047 by Greater Shoshone County Inc. and Robinson Dames &

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Moore. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84-125707; paper copy price code A10.

OFR 201-83. Evaluation of Longwall Dust Sources, by Jonathan Ludlow and Eric Marshall. April 1983. 260 pp. 72 figs. To define the relative contributions of various sources of respirable airborne dust on longwall faces, continuous dust level data were recorded on five longwalls for an average of five shifts each. Analyses of these data with records of face activity showed that it was possible to determine the overall contribution of each major element. Average levels were determined for roof support generated dust, conveyor and intake dust, and for dust levels during various shearer activities. When average levels were compared between mines, a significant degree of consistency was noted. To differentiate the various dust sources associated with the shearer, fly cuts ranging from 6 to 30 in were closely monitored as were dust levels at operator positions over the various segments of the longwall cycle. These data indicate that the clearance ring of the shearer drum is a disproportionately heavy contributor to shearer dust make. A statistical analysis of the effect of shearer haulage speed on dust make revealed that high haulage speeds are associated with low specific dust make. Research done under contract H0202016 by Foster-Miller, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Assistant Director—Mining Research, Bureau of Mines, and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84-127018; paper copy price code A12.

OFR 202-83. Geological and Geochemical Controls on the Chemical Evolution of Subsurface Water in Undisturbed and Surface-Mined Landscapes in Western North Dakota, by G. H. Groenewold, R. D. Koob, G. J. McCarthy, B. W. Rehm, and W. M. Peterson. May 1983. 292 pp. 39 figs. Studies of several surface coal mining sites in western North Dakota resulted in the development of a hydrogeochemical model that accounts for the observed chemical characteristics of subsurface water in undisturbed settings. The near-surface several meters of the landscape is constantly subjected to alternate wetting-drying, a key mechanism in hydrogeochemical evolution. The purposes of this study were to refine the model, with particular emphasis on the sulfur cycle, and to determine the applicability of the model to post-mining landscapes (spoils). Field activities included detailed ground water instrumentation of undisturbed and spoils areas at two sites. Refinement of the model included detailed analyses of the texture, bulk and clay mineralogy, sulfide abundance, and sulfur concentrations in overburden core samples. Laboratory experiments were designed to determine

the source and mechanisms of sulfate salt production from overburden samples. It was concluded that the hydrogeochemical model is equally applicable to undisturbed and spoils landscapes and that the major species of concern in this region are sodium and sulfate. It was also concluded that the major source of sulfate is sulfides in the overburden and that the solubility of sulfate in ground water in these settings is largely controlled by the sodium-calcium ratio. Research done under contract J0275010 by the North Dakota Geological Survey. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84-126952; paper copy price code A13.

OFR 203-83. Coupled-Transport Membranes for Metal Separations—Phase V, by W. C. Babcock, M. B. Chidlaw, D. J. Kelly, and E. D. LaChapelle. August 1983. 52 pp. 24 figs. This report covers phase V of a continuing program to apply a new liquid membrane process called coupled transport to the recovery of metals from hydrometallurgical leach solutions. During this phase, a membrane system of moderate scale was constructed and field-tested at the Exxon Highlands Mine and Mill Co. site near Douglas, WY. The test unit contained four hollow-fiber membrane modules, each with 100 ft² of membrane area. In the field tests, about 1,000 gallons per day of leach solution was processed. The unit was operated on the leach solution for about 50 days. Leach solution entering the unit contained 100 ppm uranium. This concentration was reduced to about 5 ppm by coupled-transport treatment, and the uranium was concentrated to about 2 wt % as a uranyl carbonate product. Under these conditions, a transmembrane uranium flux of about 2.5 lb/ft² per year was obtained. An economic analysis showed that the cost of recovering uranium from this leach solution via coupled transport is about \$1.20 per pound. At higher concentrations the cost is reduced; for example, at 1,000 ppm the cost of uranium recovery is about \$0.30 per pound. Research done under contract J0205061 by Bend Research, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and Office of Assistant Director—Minerals and Materials Research, Bureau of Mines, and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84-127034; paper copy price code A04.

OFR 204-83. Continuous Respirable Dust Monitoring System (CRDMS), by Pedro Lilienfeld, Roger Stern, and Gary Tiani. May 1983. 101 pp. 28 figs. The objective of this program was the development, design, fabrication, and laboratory testing of a mine-worthy continuous respirable dust monitoring system (CRDMS). The operation of the sensor unit of the system is based on the light scattering intensity of the respirable fraction of the airborne dust. The CRDMS is compatible with the typical environmental rigors that characterize coal mines, and, in particular, the shock, vibration, impact, moisture, and dust conditions prevailing at active mining machines. The sampled area must be within the breathing zone of the mining machine operator

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whose dust exposure is to be monitored. Instantaneous, as well as shift-averaged dust concentrations, are displayed and recorded for later retrieval. Alarm indications and other diagnostic information are provided. Research done under contract H0100110 by GCA Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Assistant Director—Mining Research, Bureau of Mines, and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84-126473; paper copy price code A06.

OFR 205-83. Environmental Assessment of Stream Pollution by Mine Drainage as a Function of Geologic Type and Reclamation Success, by H. S. Boyne, J. B. Ingwersen, J. V. Ward, Lawrence J. Gray, James Harvey, and S. L. Ponce. March 1982. 69 pp. 34 figs. The purpose of this study was to examine effects of acid mine drainage (AMD) originating from volcanic, igneous, and sedimentary watersheds in the Colorado mineral belt on stream chemistry and macroinvertebrates. Specific objectives were to (1) quantify water quality derived from mine drainage in relationship to macroinvertebrate community structure, (2) assess the natural downstream recovery rates of stream water quality and aquatic biota, and (3) compare inorganic water quality and macroinvertebrate community structure as related to the degree of reclamation success for mines located in volcanic, igneous, and sedimentary rock types. Criteria for the selection of study watersheds were a well-defined point source of AMD, presence of suitable control site, and accessibility. The selected watersheds were Kerber Creek near Villa Grove in the San Luis Valley, Peru Creek near Dillon in central Colorado, and Coal Creek near Crested Butte. The report presents results of monthly sampling conducted from July-September 1980 through May-July 1981. Kerber and Peru Creeks received AMD throughout the study period. In June 1981, a treatment plant began operations that significantly improved water quality in Coal Creek, thus allowing an assessment of reclamation success. Research done under grants G1105001 and G1115001 by the Colorado School of Mines. Available for reference at the Office of Assistant Director—Mining Research, Bureau of Mines, and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 206-83. Oxidation of Pyrite to Maghemite, by W. M. Roggenthen. October 1983. 143 pp. 54 figs. Investigation of the alteration processes of pyrite revealed that several magnetic chemical species are formed, depending upon oxygen and sulfur fugacities, temperature, and pH. Oxidation in both a dry and aqueous environment was studied. The primary purpose of the work included attempts to understand the processes wherein magnetic substances can be created from pyrite with the ultimate goal of aiding in the magnetic separation of pyrite, and hence sulfur from coal. This report presents a detailed description of the investigation. Research done under grants G1105047 and G1115461 by the South Dakota School of Mines and Technology.

Available for reference at Bureau of Mines facilities in Avondale, MD, Twin Cities, MN, Rolla, MO, Albany, OR, and Salt Lake City, UT; and Office of Assistant Director—Mining Research, Bureau of Mines, and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 207(1)-83. Metal Organic and Inorganic Affinities in Strippable Fort Union Formation Coal. Volume 1, by F. E. Diebold and Douglas Drew. September 1983. 52 pp. 35 figs. The methodology for describing the geochemistry of elements in a coal seam was developed and has been applied to the Rosebud Coal Seam, an economically important member of the subbituminous coals of the Fort Union Formation in eastern Montana. The method development involved a detailed study of two popular techniques for determining the metal geochemistry of coal, namely, whole coal analyses and coal physical fractionation. The mathematically contrived element associations and the element concentration trends in the float and sink fractions are considered to lead to only qualitative conclusions concerning the chemical associations of the elements in coals. Additionally, the processes taking place with the coal during low-temperature ashing in an oxygen plasma were experimentally investigated and shown to be of sufficient extent that the use of such low-temperature ash for deciphering element geochemistry is questionable. Volume 1 of this two-volume report presents a description of the study. Research done under grants G1105074 and G1195027 by the Montana College of Mineral Science and Technology. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; and Office of Assistant Director—Mining Research, Bureau of Mines, and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 207(2)-83. Metal Organic and Inorganic Affinities in Strippable Fort Union Formation Coal. Volume 2, by F. E. Diebold and Douglas Drew. September 1983. 139 pp. 35 figs. The methodology for describing the geochemistry of elements in a coal seam was developed and has been applied to the Rosebud Coal Seam, an economically important member of the subbituminous coals of the Fort Union Formation in eastern Montana. The method development involved a detailed study of two popular techniques for determining the metal geochemistry of coal, namely, whole coal analyses and coal physical fractionation. Volume 2 of this two-volume report contains maps and tables associated with the study. Research done under grants G1105074 and G1195027 by the Montana College of Mineral Science and Technology. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; and Office of Assistant Director—Mining Research, Bureau of Mines, and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 208-83. Derivation and Use of the Critical-Path-Method Diagram To Streamline Metallic Mining Pre-mine Stage Requirements, by Joseph M. Pugliese and

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James P. Ludwig. 1983. 28 pp. 3 figs. The Bureau of Mines, through its contract research program, recently analyzed the mining and environmental requirements in the premining stage for copper mining in the northern highland of Wisconsin using the critical-path-method (CPM). However, a step-by-step derivation of the CPM diagram was beyond the scope of the effort. The Bureau's objective now is to show, step by step, how the original hand-computed CPM diagram was constructed. The streamlining (restructuring) of the diagram from the original effort is also summarized. The critical path time (longest time) through the original CPM diagram was 25.12 yr, excluding public liaison effort. The diagram showed the involvement of the regulatory agency, mining applicant, and public in the premining stage. Analysis of the diagram produced a streamlined version that reduced the critical path time by nearly 7 yr. The CPM construction methodology may be applied to mine planning for any mining operation. Research done by the Twin Cities (MN) Research Center. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Copies of this report will not be available for purchase.

OFR 209-83. Reverse Performance Characteristics of Main Mine Fans, by M. F. Dunn, S. Bhattacharya, and V. Rajaram. August 1983. 65 pp. 25 figs. During a mine fire or other emergency, it may be desirable to reverse the airflow in order to provide an escapeway or to isolate a fire. Also, in colder areas, the airflow may be reversed to prevent ice buildup. When reversing main mine fans, the mine operator usually does not know what operating characteristics of flow and pressure to expect. Laboratory and field tests of vane-axial main mine fans in the 7- to 9-ft-diam size range were conducted to establish forward and reverse performance characteristics under controlled conditions and at typical mine installations. The data obtained suggest that reverse performance characteristics are dependent upon the blade angle and the hub-to-tip ratio. There is also evidence that reverse performance can be predicted for a family of blade angles and a given hub-to-tip ratio. Generally, quantity of air is 30% to 65% less in reverse than when operating in the normal forward mode. Research done under contract J0308044 by Engineers International, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84-143726; paper copy price code A04.

OFR 210-83. Achieving Uniform-High-Tensions in Mechanical Anchor Bolts, by Anil Mahyera and A. H. Jones. November 1982. 122 pp. 158 figs. Toward the goal of achieving uniform high tensions in roofbolts to provide superior roof support for extended periods, mechanical anchor bolts were installed in a mine in eight different ways—under torque thrust control with and without hardened

washers, Belleville washers, and tension equalization; and in a conventional manner with and without hardened washers. The various bolt groups were analyzed in terms of tension uniformity and mean tension levels. Installing the bolts accurately with hardened washers under the bolthead, and with proper torque control, resulted in the most uniformly tensioned bolts—a coefficient variation of only 14%, an improvement three times over conventional installations. Also, these bolts maintained a high tension level—80% of the installation tension compared with 50% achieved conventionally. Research done under contract H0202006 by Terra Tek, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84-143718; paper copy price code A06.

OFR 211-83. Recommendations for Human Factors Research and Development Projects in Surface Mining, by Ernest J. Conway and Mark S. Sanders. May 1982. 86 pp. 10 figs. To facilitate the planning of future research within the Bureau of Mines, 74 human factors research and development projects were identified for possible Bureau funding. The projects were based on (1) literature surveys, (2) reviews of accident statistics and reports, (3) interviews with equipment manufacturers, Mine Safety and Health Administration (MSHA) and Bureau personnel, and (4) site visits to 26 mines. The projects were divided into categories related to (1) mobile equipment, (2) maintenance shops and areas, (3) plans and mills, (4) organizational factors, (5) safety programs data, and (6) training. The projects were placed into three categories of priority and were rated by industry and MSHA people in terms of benefit to the industry. The highest priority contained 25 projects with 26 in category 2, and 23 projects in the lowest category. Research done under contract J0395080 by Canyon Research Group, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84-143650; paper copy price code A05.

OFR 212-83. CMI Inert Gas Mine Firefighting System, by M. Paczkowski, G. A. Tracey, and A. Wojtyczka. February 1982. 58 pp. 23 figs. The use of inert gas systems to extinguish mine fires has been the subject of research for some time in the United States. In some European countries it is an established practice. Tests were conducted with the Central Mining Institute (CMI) Inert Gas System, which is being used by the Polish mining industry. This system utilizes a modified jet aircraft engine and afterburner as a compact source of combustion products with a very low oxygen content. Water injected into the combustion products stream provides evaporative cooling and forms a mist with a high cooling capacity. The CMI system was used under controlled conditions to extinguish coal pile fires at the Bureau of Mines Experimental Mine in Brucecon, PA. The tests results show that the CMI system can be used conveniently to extin-

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guish fires quickly and to maintain an inert atmosphere in the fire zone to prevent reignition. Research done under contract J0318080 by CSE Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Juneau, AK, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Surface Mining Library and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84-142678; paper copy price code A04.

OFR 213-83. Slack and Overload Rope Protection System, by Holt L. Farley, Roger B. Fish, Robert L. Jeffcoat, and David L. Hoadley. January 1983. 327 pp. 71 figs. This report describes the development of an electronic system that detects unsafe slack and overload conditions in underground mine hoist ropes. The slack and overload rope protection system (SORPS) includes a fail-safe load cell inserted between the rope and the conveyance and an accelerometer mounted on the conveyance. Signals from these transducers are telemetered via a radio link to the hoist control room where they are combined with drum speed and chair status in a microprocessor-based decision and display unit. Abnormally high external force levels are detected as discrepancies between rope and tension and cage acceleration; conveyance weight is inferred continuously. Hazardous conditions and general hoist status are displayed to the hoist operator. The system has been tested in a working mine for approximately 2 years. The report contains specifications, design data, and field test experience generated under the SORPS program. Information on dynamic modeling, vibration environment, status of existing slack detection systems, and applicable control strategies are included. Research done under contract J0199008 by Foster-Miller Associates, Inc. Available for reference at Bureau of Mines facilities in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; National Mine Health and Safety Academy, Beckley, WV; and Office of Assistant Director—Mining Research, Bureau of Mines, and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84-143460; paper copy price code A15.

OFR 214-83. Reclamation of Tailing Basins Resulting From Copper-Nickel Milling, by John P. Borovsky, David F. Grigal, and Ricki L. Strassman. August 1983. 149 pp. 34 figs. A 3-year study was conducted to evaluate the problems and benefits of using vegetation to stabilize tailing from a potential Minnesota copper-nickel milling operation with the major objective of developing a feasible method for revegetation. Secondary objectives were to (1) describe the physical and chemical characteristics of copper tailing and determine the potential influence of those characteristics on plant growth, (2) identify alternative plant species and soil management techniques useful in the revegetation of copper-nickel tailing, (3) evaluate the effects of vegetation establishment on the liberation of potentially toxic metals in tailing drainage water, and (4) assess the accumulation of potentially toxic metals in vegetation grown in copper-nickel tailing. Research done under contract J0205050 by Barr Engineering Co. Available for reference at Bureau of Mines facilities

in Denver, CO, Twin Cities, MN, Pittsburgh, PA, and Spokane, WA; and Office of Assistant Director—Mining Research, Bureau of Mines, and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84-142587; paper copy price code A07.

OFR 215(1)-83. Basic Research on Coal Fragmentation and Dust Entrainment. Volume I—Technical Information, by Gary L. Stecklein, Ronald Branstetter, Roy Arrowood, David Davidson, James Lankford, Robert Lyle, and Carter Nulton. June 1982. 123 pp. 66 figs. This report summarizes the results of research into the areas of the fragmentation and entrainment of airborne respirable dust (ARD). The objectives of the program were fourfold: First, to review the present state of knowledge regarding ARD; second, to expand this state of knowledge through the identification of hypothetical microscopic mechanisms by which the coal is fragmented and the dust becomes entrained; third, to specify the informational requirements to verify or nullify these hypotheses; and fourth, to relate experimental techniques that will produce that required information. Additionally, insights are provided regarding potential methods of extraction and/or treatment that may reduce the concentration of ARD. Volume I presents the technical information on the investigation. Research done under contract J0215009 by Southwest Research Institute. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; and Office of Assistant Director—Mining Research, Bureau of Mines, and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84-143445; paper copy price code A06.

OFR 215(2)-83. Basic Research on Coal Fragmentation and Dust Entrainment. Volume II—Appendix Information, by Gary L. Stecklein, Ronald Branstetter, Roy Arrowood, David Davidson, James Lankford, Robert Lyle, and Carter Nulton. June 1982. 168 pp. 33 figs. This report summarizes the results into the areas of the fragmentation and entrainment of airborne respirable dust (ARD). The objectives of this program were fourfold: First, to review the present state of knowledge regarding ARD; second, to expand this state of knowledge through the identification of hypothetical microscopic mechanisms by which the coal is fragmented and the dust becomes entrained; third, to specify the informational requirements to verify or nullify these hypotheses; and fourth, to relate experimental techniques that will produce that required information. Additionally, insights are provided regarding potential methods of extraction and/or treatment that may reduce the concentration of ARD. Volume II contains the appendix. Research done under contract J0215009 by Southwest Research Institute. Available for reference at Bureau of Mines facilities in Tuscaloosa, AL, Denver, CO, Avondale, MD, Twin Cities, MN, Rolla, MO, Reno, NV, Albany, OR, Pittsburgh, PA, Salt Lake City, UT, and Spokane, WA; Mine Safety and Health Administration, Arlington, VA; and Office of Assistant Director—Mining Research, Bureau of Mines, and the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Order ONLY from NTIS: PB 84-143452; paper copy price code A08.

MINERAL LAND ASSESSMENTS

The following reports, part of a continuing series of Mineral Land Assessment reports, are available for consultation at the Bureau of Mines, Field Assessment and Evaluation Program Staff, Washington, DC, and at the Natural Resources Library, U.S. Department of the Interior, Washington, DC. Specific reports are also available at the field office indicated following their titles.

NOTE: The Eastern Field Operations Center, Pittsburgh, PA, was closed permanently on October 1, 1983. Reports formerly available at the Eastern Field Operations Center are now available at the Intermountain Field Operations Center, Denver, CO.

- MLA 1-83.** Mineral Investigation of the North End Roadless Area, Cochise County, Arizona, by Philip R. Bigsby. 1983. 22 pp. 2 figs. Intermountain Field Operations Center, Denver, CO.
- MLA 2-83.** Mineral Investigation of Blood Mountain RARE II Further Planning Area and Raven Cliff RARE II Wilderness Area, Lumpkin, Union, and White Counties, Georgia, by Michelle K. Armstrong and Andrew E. Sabin. 1982. 22 pp. 4 figs. Eastern Field Operations Center, Pittsburgh, PA.
- MLA 3-83.** Mineral Investigation of the Wheeler Ridge RARE II Area (No. 5040), Inyo and Mono Counties, California, by Donald O. Capstick. 1983. 9 pp. 1 fig. Western Field Operations Center, Spokane, WA.
- MLA 4-83.** Mineral Investigation of Dolus Lakes RARE II Area (No. 1429), Granite and Powell Counties, Montana, by Dale William Avery. 1983. 20 pp. 1 fig. Western Field Operations Center, Spokane, WA.
- MLA 5-83.** Mineral Investigation of the Marble Mountain Wilderness (FS), Siskiyou County, California, by William N. Hale and Gary J. Cwick. 1983. 21 pp. 1 fig. Western Field Operations Center, Spokane, WA.
- MLA 6-83.** Mineral Investigation of the Deschutes Canyon RARE II Area (No. 6321), Jefferson and Deschutes Counties, Oregon, by Richard A. Winters. 1983. 8 pp. 1 fig. Western Field Operations Center, Spokane, WA.
- MLA 7-83.** Mineral Investigation of the Lost Creek RARE II Area (No. 5089), Shasta County, California, by Harry W. Campbell. 1983. 9 pp. 1 fig. Western Field Operations Center, Spokane, WA.
- MLA 8-83.** Mineral Investigation of the Castle Crags RARE II Area (No. B5219), Siskiyou and Shasta Counties, California, by James M. Spear. 1983. 10 pp. 1 fig. Western Field Operations Center, Spokane, WA.
- MLA 9-83.** Mineral Investigation of the Sugarloaf RARE II Area (No. 5186), San Bernardino County, California, by Harry W. Campbell. 1983. 18 pp. 1 fig. Western Field Operations Center, Spokane, WA.
- MLA 10-83.** Mineral Investigation of the Sill Hill RARE II Area (No. 5304), San Diego County, California, by Thomas J. Peters. 1983. 13 pp. 1 fig. Western Field Operations Center, Spokane, WA.
- MLA 11-83.** Mineral Investigation of the Bear Canyon RARE II Area (No. 5104), Monterey County, California, by John R. Benham. 1983. 7 pp. 1 fig. Western Field Operations Center, Spokane, WA.
- MLA 12-83.** Mineral Investigation of the Big Rocks RARE II Area (No. 5112), San Luis Obispo County, California, by Lucia Kuizon. 1983. 8 pp. 1 fig. Western Field Operations Center, Spokane, WA.
- MLA 13-83.** Mineral Investigation of the Machesna Mountain RARE II Area (No. 5110), San Luis Obispo County, California, by Lucia Kuizon. 1983. 11 pp. 1 fig. Western Field Operations Center, Spokane, WA.
- MLA 14-83.** Mineral Investigation of the Mount Adams Wilderness Study Area and Adjacent Mount Adams RARE II Area A6069 (FS), Skamania and Yakima Counties, Washington, by Michael S. Miller. 1983. 15 pp. 1 fig. Western Field Operations Center, Spokane, WA.
- MLA 15-83.** Mineral Investigation of the Sheep Divide RARE II Area (No. 6602), Wallowa County, Oregon, by Harry W. Campbell. 1983. 7 pp. 1 fig. Western Field Operations Center, Spokane, WA.
- MLA 16-83.** Mineral Investigation of the Glacier View RARE II Area (No. A6061), Pierce County, Washington, by Donald J. Barnes. 1983. 11 pp. 1 fig. Western Field Operations Center, Spokane, WA.
- MLA 17-83.** Mineral Investigation of the Spoor Canyon RARE II Area (No. 5118), Santa Barbara County, California, by John R. Benham. 1983. 7 pp. 1 fig. Western Field Operations Center, Spokane, WA.
- MLA 18-83.** Mineral Investigation of the Horseshoe Springs RARE II Area (No. 5115), Santa Barbara County, California, by Michael C. Horn. 1983. 9 pp. 1 fig. Western Field Operations Center, Spokane, WA.
- MLA 19-83.** Mineral Investigation of the Miranda Pine RARE II Area (No. 5114), Santa Barbara County, California, by Lucia Kuizon. 1983. 8 pp. 1 fig. Western Field Operations Center, Spokane, WA.
- MLA 20-83.** Mineral Investigation of the Wenaha-Tucannon Wilderness Study Area (FS), Asotin, Columbia, and Garfield Counties, Washington, Wallowa County, Oregon, by Steven R. Munts. 1983. 17 pp. 2 figs. Western Field Operations Center, Spokane, WA.
- MLA 21-83.** Mineral Investigation of the Lime Hills, Narrows, and Sand Cove Wilderness Study Areas, Mohave County, Arizona, by John P. Briggs. 1983. 13

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- pp. 2 figs. Intermountain Field Operations Center, Denver, CO.
- MLA 22-83. Mineral Investigation of the Selkirks RARE II Areas (Nos. A, B, C, D-1125), Boundary County, Idaho, by John R. Benham. 1983. 8 pp. 1 fig. Western Field Operations Center, Spokane, WA.
- MLA 23-83. Mineral Investigation of the Olallie RARE II Area (No. 6099), Marion and Jefferson Counties, Oregon, by Terry R. Neumann. 1983. 11 pp. 1 fig. Western Field Operations Center, Spokane, WA.
- MLA 24-83. Mineral Investigation of the Chancelulla RARE II Area (No. 5220), Trinity County, California, by Scott A. Stebbins. 1983. 11 pp. 1 fig. Western Field Operations Center, Spokane, WA.
- MLA 25-83. Mineral Investigation of the Cactus Springs RARE II Area (No. A5188), Riverside County, California, by Lucia Kuizon. 1983. 11 pp. 1 fig. Western Field Operations Center, Spokane, WA.
- MLA 26-83. Mineral Investigation of the Greenhorn Mountain Wilderness Study Area, Huerfano and Pueblo Counties, Colorado, by G. David Baskin. 1983. 16 pp. 3 figs. Intermountain Field Operations Center, Denver, CO.
- MLA 27-83. Mineral Investigation of the West Face Sacramento Mountains Roadless Area, Otero County, New Mexico, by John P. Briggs. 1983. 14 pp. 2 figs. Intermountain Field Operations Center, Denver, CO.
- MLA 28-83. Mineral Investigation of the Raywood Flats RARE II Area (No. B5187), Riverside and San Bernardino Counties, California, by Stephen R. Iverson. 1983. 12 pp. 1 fig. Western Field Operations Center, Spokane, WA.
- MLA 29-83. Mineral Investigation of the Bald Rock RARE II Area (No. 5169), Butte County, California, by Alan R. Buehler. 1983. 11 pp. 1 fig. Western Field Operations Center, Spokane, WA.
- MLA 30-83. Mineral Investigation of the Heart Lake (5096) and Wild Cattle Mountain (5093) RARE II Areas, Plumas, Shasta, and Tehama Counties, California, by David K. Denton, Jr., and Donald E. Graham. 1983. 9 pp. 1 fig. Western Field Operations Center, Spokane, WA.
- MLA 31-83. Mineral Investigation of the Indian Heaven RARE II Area (No. 6076), Skamania County, Washington, by Donald J. Barnes. 1983. 11 pp. 1 fig. Western Field Operations Center, Spokane, WA.
- MLA 32-83. Mineral Investigation of the Butt Mountain (No. 5100), Ishi (No. B5098), Mill Creek (No. 5284), and Polk Springs (No. 5097), RARE II Areas, Tehama and Plumas Counties, California, by Eric E. Cather, Harry W. Campbell, David K. Denton, Jr., and Peter N. Gabby. 1983. 13 pp. 1 fig. Western Field Operations Center, Spokane, WA.
- MLA 33-83. Mineral Investigation of an Addition to the White Mountain Wilderness, Lincoln County, New Mexico, by John P. Briggs. 1983. 11 pp. 2 figs. Intermountain Field Operations Center, Denver, CO.
- MLA 34-83. Mineral Investigation of the North Fork John Day River RARE II Area (No. B6253), Grant County, Oregon, by Martin D. Conyac. 1983. 16 pp. 1 fig. Western Field Operations Center, Spokane, WA.
- MLA 35-83. Mineral Investigation of the West Needle Wilderness Study Area and the BLM West Needle Contiguous Wilderness Study Area, La Plata and San Juan Counties, Colorado, by David C. Scott. 1983. 47 pp. 8 figs. Intermountain Field Operations Center, Denver, CO.
- MLA 36-83. Mineral Investigation of the Condrey Mountain RARE II Area (Nos. 5704 and 6704), Siskiyou County, California, by Ronald T. Mayerle. 1983. 16 pp. 1 fig. Western Field Operations Center, Spokane, WA.
- MLA 37-83. Mineral Investigation of the Wildrose Canyon Wilderness Study Area (BLM), CDCA-060-134, Inyo County, California, by Spencee L. Willett. 1983. 7 pp. 1 fig. Western Field Operations Center, Spokane, WA.
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ARTICLES IN OUTSIDE PUBLICATIONS

The following articles have appeared in the outside press. Copies of these articles are NOT available from the Bureau of Mines.

- OP 1-83. Changing Patterns in Industrial Demand for Sulphur**, by D. E. Morse and J. E. Shelton. Paper in International Conference Sulphur '82, Proceedings of the Conference, Volume 1: Preprints, ed. by A. I. More (London, Nov. 14-17, 1982). The British Sulphur Corp. Ltd., London, 1982, pp. 9-19. An attempt has been made to project the level of U.S. industrial sulfur demand in 1990, using various macroeconomic indicators, and using the United States as a model for the world as a whole, a further projection of total world industrial sulfur demand has been made. The potential world demand for current industrial uses for sulfur by 1990 is estimated to be 31.6 million metric tons. The most promising new uses for sulfur are believed to be in road paving materials and sulfur concrete. The potential world demand for new uses by 1990 is estimated to be 6.0 million metric tons. Thus, the total demand for industrial uses in 1990 is projected to be 37.6 million metric tons, which represents an annual growth rate of 5.4 pct from 1981 to 1990.
- OP 2-83. Overview of Bureau of Mines Coal Mine Research**, by John N. Murphy. Paper in Proc. 13th Annu. Inst. on Coal Min. Health, Safety, and Res. (VA Polytech. Inst., Blacksburg, VA, Aug. 24-26, 1982). VA Polytech. Inst., 1982, pp. 70-95. The Bureau of Mines mining research program is divided into two principal problem areas: (1) health and safety and (2) conservation and development. This paper focuses on the Bureau's coal mine health and safety research program and emphasizes recent accomplishments or new developments that will shortly be available for use by the industry.
- OP 3-83. Comparison of Methods for Recovering Metal Values From Salton Sea KGRA Brines**, by L. E. Schultze and D. J. Bauer. Geothermal Resour. Council Trans., v. 6, Oct. 1982, pp. 111-113. The Bureau of Mines is investigating methods for recovering metal values from geobines. Two precipitation techniques were evaluated for recovering selected metal values from Salton Sea Known Geothermal Resource Area brines. Lime addition precipitates more than 95 pct of the iron, manganese, lead, and zinc, while sulfide addition precipitates more than 90 pct of the lead and zinc and lesser amounts of iron and manganese. A comparison of these techniques and a discussion of the respective advantages and disadvantages are presented.
- OP 4-83. Dewatering and Consolidation of Coal-Clay Tailing From Preparation Plants**, by B. J. Scheiner and P. M. Brown. Paper in Proceedings of the Consolidations and Dewatering of Fine Particles Conference (cosponsored and pub. by BuMines, Univ. of AL College of Eng., and AL Min. and Miner. Resour. Inst., University, AL, Aug. 10-12, 1982), 1982, pp. 133-151. The Bureau of Mines is conducting research on a novel method for dewatering coal-clay waste as an alternative to ponding now being practiced by the industry. The method consists of mixing coal-clay waste with a flocculant, polyethylene oxide (PEO), and dewatering the resulting flocs in a hydrosieve screen. The technique is being tested in a unit operating at 400 gal/min, located at the Jim Walter's No. 7 Mine in Brookwood, AL. In continuous tests, coal-clay waste has been dewatered from a nominal 3 pct solids to products ranging from 50 to 60 pct solids. When placed in a pit, the dewatered material continues to consolidate to 70 pct solids in several days.
- OP 5-83. A Progress Report on Large-Scale Dewatering Tests of Northern Florida Phosphate Clay Waste**, by Annie G. Smelley, B. J. Scheiner, and D. R. Brooks. Paper in Proceedings of the Consolidation and Dewatering of Fine Particles Conference (cosponsored and pub. by BuMines, Univ. of AL College of Eng., and AL Min. and Miner. Resour. Inst., University, AL, Aug. 10-12, 1982), 1982, pp. 265-284. The Bureau of Mines is testing a dewatering technique for phosphate clay waste that will recover a portion of the water now being lost using conventional waste disposal methods and produce solids suitable for land reclamation. The technique uses a flocculant, polyethylene oxide (PEO), that forms strong, stable flocs that can be dewatered on a static screen followed by further dewatering on a rotary screen. In field tests conducted in northern Florida, clay wastes containing a nominal 2.5 pct solids have been consolidated to greater than 20 pct solids. The rate at which PEO-treated material continues to dewater in a mine cut is also being investigated. Preliminary results indicate that PEO-treated material will dewater to 29 pct solids in 127 days.
- OP 6-83. Quantitative Measurement of Polymeric Bonds Using Viscometric Techniques**, by D. A. Stanley, S. W. Webb, and B. J. Scheiner. Paper in Proceedings of the Consolidation and Dewatering of Fine Particles Conference (cosponsored and pub. by BuMines, Univ. of AL College of Eng., and AL Min. and Miner. Resour. Inst., University, AL, Aug. 10-12, 1982), 1982, pp. 468-490. The amount of polyethylene oxide (PEO) required to dewater calcium-exchanged montmorillonite is affected by shear stresses, both during mixing of the clay and polymer and during mechanical deformation of the flocculated mass to remove water. The Bureau of Mines measured changes in viscosity with time at a constant rate of shear for shear rates up to 350 per minute for PEO-montmorillonite mixtures. The energy density of the bonds formed by the PEO-montmorillonite complex then was calculated for two different bond systems. These different bond systems are present because the fundamental clay particles form flocs that are bridged to form aggregates of flocs. The implications of these results as they relate to PEO dewatering of phosphatic clay waste are discussed.

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OP 7-83. Using Retroreflective Material To Enhance the Conspicuity of Coal Miners, by Barry H. Beith, Mark S. Sanders, and James M. Peay. *Human Factors*, v. 24, No. 6, Dec. 1982, pp. 727-735. This study investigated the use of retroreflective material to increase conspicuity of miners. A scaled simulation was created using dolls configured as miners. Twelve observers viewed four configurations of retroreflective material on dolls in 3 body postures at 1 of 3 locations in the visual field. In a subsequent experiment, nine observers compared two configurations. The results confirmed the poor conspicuity of the configuration currently required in mines, which features retroreflective tape on the helmet only. All experimental retroreflective configurations significantly improved detectability over this configuration. Overall, the most cost-effective configurations were those in which the belt and/or armbands were covered with retroreflective material.

OP 8-83. Rapid-Sampling System for Dusts and Gases, by R. S. Conti, M. Hertzberg, F. T. Duda, and K. L. Cashdollar. *Rev. Sci. Instrum.*, v. 54, No. 1, Jan. 1983, pp. 104-108. The Bureau of Mines researched a system for the rapid grab sampling of heterogeneous mixtures of gases and dusts during the preignition and postignition stages of dust explosions. The combustion chamber in which the explosion occurs is first fitted with a hypodermic sampling needle with its inlet end at the desired sampling point within the chamber and its sharp, injecting end protruding outside of the chamber. Rapid sampling (approximately 25 to 50 ms) is achieved with a double-acting, air-pressure-actuated cylinder. The forward stroke of the cylinder thrusts the rubber septum seal of an evacuated glass sampling tube onto the protruding needle, which punctures the septum, filling the tube with gas and dust from the combustion chamber. The return stroke of the cylinder reseals the sampling tube by returning the mechanism to its original position. The initial time of sampling and the duration of sampling are independently variable and controlled by a microprocessor. Results obtained with a trimodal distribution of coal dust show no significant size discrimination at least up to 70 μm . Data obtained from laboratory-scale coal dust explosion tests are also presented. Such data provide valuable insights into the basic phenomena involved in explosions.

OP 9-83. Assessment of Effectiveness of Janelid Ventilation, by A. Erickson, K. Heller, and E. Thimons. *Min. Congr. J.*, v. 68, No. 10, Oct. 1982, pp. 39-44. The effectiveness of a loader-mounted fan on diesel vehicles combined with natural convection of a dead heading (the patented Janelid system) was investigated experimentally. The results were obtained using CO_2 as a tracer gas in a one-quarter-scale model heading. Buoyant forces were scaled to establish similarity with full scale. For a loader moving in a typical load-haul-dump cycle, the loader-mounted fan reduced the tracer gas concentration by 26 pct compared with a reduction of 32 pct for a jet fan of four times the flow capacity.

OP 10-83. Statistical Thermodynamics of Long-Range Order, by N. A. Gokcen. *Scr. Metall.*, v. 17, No. 1, 1983, pp. 53-58. Statistical thermodynamics of long-range order are part of the Bureau of Mines program to provide a scientific base for use in developing new alloys and alloy phases. Numerous statistical thermodynamic attempts have been made to formulate the behavior of long-range order in alloys after the work of Gorsky, and Bragg and

Williams (GBW). The quasichemical method is often erroneously claimed to be an improvement over the GBW method. The permutation of the bonds in the quasichemical method is made to become the permutation of atoms for zero exchange energy, or when the temperature is sufficiently high, through a dubious normalization process. The normalization process of the quasichemical method yields the same equations for the excess Gibbs energy of solution as without normalization, and the actual enumerations of configurations prove that the permutable entities are the atoms, not the bonds. This communication has a twofold purpose: (1) to show that the permutation of atoms yields proper new equations for order-disorder phenomena after reasonable corrections and (2) to discuss the errors in the previous regular assembly treatments.

OP 11-83. Computer Model Simulates Screening Process Under Variety of Conditions. Semi-Empirical Approach Allows Researchers More Latitude. Part I, by Douglas C. Grant, Kevin Hennings, Thomas Bobick, and Roy Bartholomae. *Pit & Quarry*, v. 75, No. 5, Nov. 1982, pp. 59-63. A U.S. Bureau of Mines sponsored program was undertaken by the Advanced Technology Center of Allis-Chalmers Corp. to improve performance modeling of vibrating machines. This work was requested to increase public knowledge of screening performance with emphasis on the performance of nonmetallic decks. The program included extensive testing on a special vibrating screen test apparatus, development of a mathematical model of screening behavior, and incorporation of simulation parameters. The test fixtures and mathematical model are described, and the mathematical results are compared with screen test data.

OP 12-83. Computer Model Simulates Screening Process Under Variety of Conditions. Semi-Empirical Approach Allows Researchers More Latitude. Part II, by Douglas C. Grant, Kevin Hennings, Thomas Bobick, and Roy Bartholomae. *Pit & Quarry*, v. 75, No. 6, Dec. 1982, pp. 67-68. A U.S. Bureau of Mines sponsored program was undertaken by the Advanced Technology Center of Allis-Chalmers Corp. to improve performance modeling of vibrating machines. This work was requested to increase public knowledge of screening performance with emphasis on the performance of nonmetallic decks. The program included extensive testing on a special vibrating screen test apparatus, development of a mathematical model of screening behavior, and incorporation of simulation parameters. The test fixtures and mathematical model are described, and the mathematical results are compared with screen test data.

OP 13-83. A Review of the Deposits and Beneficiation of Lower-Grade Chromite, by Ralph H. Nafziger. *J. South African Inst. Min. and Metall.*, v. 82, No. 8, Aug. 1982, pp. 205-226. This paper reviews the major deposits of lower grade chromite in the world and a wide variety of methods used for the recovery of chromium from these deposits. Gangue materials in more coarsely sized ores can be separated by gravity means, whereas flotation techniques are required for finer grained materials. However, unless there is considerable iron in the ores, physical means cannot increase the Cr-Fe ratios. Chemical techniques such as hydrometallurgical methods, chlorination, roasting and leaching, and smelting are required for this purpose. A greater understanding of the physical properties of chromites and the chemical reactions that take place in the recovery operations is required before the recoveries from lower grade chromites can be

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maximized. More efficient recovery operations can be realized if it can be shown definitively that the reduction of chromites occurs via either a gas-solid or solid-solid mechanism, for example. The effects of specific impurities on the chromite reduction reactions need to be better understood, as do reagent and pH control in the flotation of chromite.

OP 14-83. Alaska Mining in '83: From Gold to Hardrock & Gravel. The Dollars Are Changing Direction, by Tom L. Pittman and John J. Mulligan. *Alaska Construction & Oil*, v. 24, No. 1, Jan. 1983, pp. 21-23. This article describes the changing mineral industry and mineral-related activities in Alaska. The sand and gravel industry, placer gold production, mineral legislation, U.S. Bureau of Mines activities, and other developments are discussed.

OP 15-83. Are Zeolites Dimensionally Equivalent to Asbestos? By K. B. Shedd, R. L. Virta, and A. G. Wylie. Paper in *Process Mineralogy II: Applications to Metallurgy, Ceramics and Geology* (Proc. Symp. sponsored by Metall. Soc. AIME, Dallas, TX, Feb. 15-18, 1982). Metall. Soc. AIME, 1983, pp. 395-399. Questions regarding possible health effects from exposure to zeolites arose when the inhabitants of two villages in Turkey were found to have high incidences of mesothelioma, a disease generally identified with exposure to asbestos. No asbestos deposits are known in the area, but some fibrous zeolites have been found. Further investigations have resulted in conflicting opinions as to whether fibrous zeolites are related to the high incidence of mesothelioma in Turkey. The U.S. Bureau of Mines examined the habits of domestic zeolites by scanning and transmission electron microscopy. Only erionite and mordenite particles possessed acicular to fibrous habits. With the exception of a rarely occurring wooly erionite sample, the fibrous zeolites were not dimensionally equivalent to asbestos.

OP 16-83. Effect of Ferrous Scrap Composition Changes on the Quality of Iron and Steel Castings, by W. L. Swager, H. W. Lownie, Jr., C. E. Mobley, and R. H. Nafziger. *Am. Foundrymen's Soc. Trans.*, v. 90, 1982, pp. 811-819. Because the foundry industry has expressed concern over the possible deterioration of ferrous scrap used as charge material for iron-making and steelmaking, the Bureau of Mines contracted with Battelle's Columbus Laboratories to determine the extent of the problem and what might be done. Data obtained from the literature, scrap processors and brokers, practicing foundry operators, and trade associations indicate no substantial evidence to support the thesis that the quality of purchased ferrous scrap available to foundries is expected to decline significantly during the next decade. Tramp elements already present will continue to be present in purchased scrap, with B, Cr, Pb, and Sb in iron and Sb, P, and S in steel being of most concern. Continuing lot-to-lot variation will make quality control by foundries increasingly important. Foundries and their suppliers of purchased scrap have the potential to control tramp elements within practical limits. Costs will increase in the long term owing to increased demand for premium grades of scrap, necessary upgrading of scrap to maintain low-tramp levels, and increased expenses to control tramp elements.

OP 17-83. Mineralogy and Beneficiation of Phosphate-Bearing Rocks From Northern Michigan, by

Lawrence L. Brown, Albert R. Rule, and Charles B. Dallenbach. Pres. at TMS-AIME Annu. Meeting, Dallas, TX, Feb. 14-16, 1982. Paper in *Process Mineralogy II: Applications in Metallurgy, Ceramics, and Geology*, ed. by R. D. Hagni. Metall. Soc. AIME, Warrendale, PA, pp. 119-133. As part of the Federal effort to help maintain an adequate supply of fertilizer materials, the Bureau of Mines conducted research to characterize complex low-grade Michigan phosphate materials and to devise methods for recovering fertilizer-grade phosphate concentrates. The rock is from middle Precambrian sedimentary formations in the Marquette Range located in the central part of the Upper Peninsula of Michigan. Occurrence of phosphate-bearing sediments in Precambrian rocks is rare. This deposit, containing 12 to 15 pct P_2O_5 , is believed to be the richest Precambrian phosphate deposit in the United States. Petrographic examination showed that the conglomeritic rock contains crystalline apatite both in "black pebbles" and in quartz matrix. Attrition scrubbing and sizing tests showed that there is no tendency for phosphate to concentrate in any of the sized fractions. In beneficiation tests, which included grinding to minus 325 mesh followed by phosphate mineral flotation using a fatty acid-fuel oil collector, a phosphate concentrate was obtained that had a grade of 30 pct P_2O_5 and a P_2O_5 recovery of 72 pct. This concentrate should be suitable for fertilizer manufacture.

OP 18-83. Mathematical Modeling of Spontaneous Combustion of Coal, by John C. Edwards. Pres. at 112th TMS-AIME Annu. Meeting, Atlanta, GA, Mar. 6-10, 1983; TMS Paper Selection A83-21, 16 pp. A mathematical model of spontaneous combustion of coal in a pile was developed. The model simulates under the condition of constant unidirectional flow of air through a bed of uniform coal particles, the temperature rise in the air-and-particle system associated with a first order Arrhenius particle surface reaction. The following transport mechanisms are included: (1) heat conduction into the particle interior, (2) oxygen depletion due to particle surface reaction, (3) diffusion and forced convection of oxygen, and (4) heat conduction and convection in the air. The model is developed as a set of coupled partial differential equations that are solved numerically. A parametric analysis is made of particle size, inlet air temperature, particle packing, and ventilation velocity on the time required for thermal ignition to occur and the depth in the bed at which it occurs.

OP 19-83. Activity Coefficients of Solutes in Binary Solvents, by N. A. Gokcen. *High Temp. Sci.*, v. 15, Mar. 10, 1983, pp. 293-300. The activity coefficients in dilute ternary systems are discussed in detail by using the Margules equations. Analyses of some relevant data at high temperatures show that the sparingly dissolved solutes in binary solvents follow complex behavior even when the binary solvents are very nearly ideal. It is shown that the activity data on the solute or the binary system cannot permit computation of the remaining activities except for the regular solutions. It is also shown that a fourth-order equation is usually adequate in expressing the activity coefficient of a solute in binary solvents at high temperatures. When the activity data for a binary solvent are difficult to obtain in a certain range of composition, the activity data for a sparingly dissolved solute can be used to supplement determination of the binary activities.

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OP 20-83. Determination, Estimation, and Correlation of Activities in Hydrometallurgical Ionic Solutions, by N. A. Gokcen. Pres. at 112th AIME Annu. Meeting, Atlanta, GA, Mar. 6-10, 1983; proc. 3d Int. Symp. on Hydrometallurgy, Dec. 15, 1982, pp. 329-340. Methods of rapid determination, estimation, and correlation of aqueous ionic activities are briefly discussed. New data are presented for binary solutions of AlCl_3 , $\text{Al}(\text{NO}_3)_3$, CrCl_3 , CuSO_4 , NaCl , and ZnSO_4 . These and other data are used to discuss the limitations of estimation methods.

OP 21-83. U.S. Short-Term Demand Outlook for Soda Ash and Factors Affecting U.S. Soda Ash Availability in the World Market, by Dennis S. Kostick. Chem. and Ind. (London), No. 4, Feb. 21, 1983, pp. 161-165. Soda ash has been used in the United States for nearly 300 years and it is not surprising that most of the end uses have reached maturity and tend to follow the population trend, which for the last several years has been leveling out. The major soda ash markets in the United States are similar to those in other industrially developed countries, namely glass, chemicals, soaps and detergents, pulp and paper, and water treatment. Most of these industries throughout the world have been affected by the general downturn in the world economy, which, in turn, has affected soda ash demand. This paper concentrates on the short-term outlook for soda ash consumption in the United States and some of the factors that will affect the availability of U.S. soda ash for export.

OP 22-83. Reparameterization of the Becker-Kistiakowsky-Wilson Equation of State for Water-Gel Explosives, by V. Krishna Mohan and J. Edmund Hay. Combust. and Flame, v. 50, 1983, pp. 207-218. This paper describes the results of the reparameterization studies on the Becker-Kistiakowsky-Wilson (BKW) equation of state for water-gel explosives. The original set of BKW parameters ($\alpha = 0.5$, $\beta = 0.1$, $K = 11.85$, and $\theta = 400$) predicts a higher detonation velocity and detonation pressure and a lower detonation temperature compared with the experimental values for these explosives. Among the several combinations of parameters examined, the following set— $\alpha = 0.5$, $\beta = 0.1$, $K = 8.85$, and $\theta = 1,850$ —is found to give realistic values for the various detonation properties. Moreover, the predicted and the experimental detonation velocities are seen to be in fair agreement. A comparison of the computed and the experimental (obtained from Crawshaw-Jones measurements) fume characteristics show that (1) inclusion of the wrapper material in the explosive composition increases the concentration of fumes and gives correspondence between the two products such as CO , H_2 , NH_3 , and CH_4 ; (2) the measured NO_x concentration is difficult to get in these computations; and (3) calculations of the product compositions for the isentropic expansion of destination products along the Chapman-Jouguet isentrope give freeze-out temperatures in the range of 1,000 to 1,800 K. These computations were also performed for two ammonium nitrate-fuel oil mixtures and were found to be in good agreement with the experimental data.

OP 23-83. Prereduction and Melting of Domestic Titaniferous Materials, by R. H. Nafziger and R. R. Jordan. Metall. Trans. B, v. 14B, No. 1, Mar. 1983, pp. 55-62. Two domestic ilmenites and one titaniferous magnetite were prereduced by the Bureau of Mines in a batch rotary kiln with coal char to assess the feasibility of this technique in improving melting operations and subsequent electric furnace processing. All three prereduced titaniferous ma-

terials were melted satisfactorily in an electric arc furnace to produce iron as a metal suitable for further refining to steel; metallizations ranging from 63 to 83 pct of the iron oxides were achieved. The ilmenites yielded titanium-enriched slags that were amenable to further processing by conventional methods. Prereduction decreased electrode consumption during furnace operation and also conserved expensive electrical energy that otherwise must be used to reduce and melt totally the entire titaniferous materials charge.

OP 24-83. Chelating Crosslinked Starches as Flocculants for Oxide and Hydroxide Mineral Fines, by S. C. Termes and R. L. Wilfong. Pres. at 112th AIME Annu. Meeting, Atlanta, GA, Mar. 6-10, 1983. SME Preprint 83-195, pp. 1-9. As part of an effort to provide basic data on the fundamental scientific and engineering principles of minerals beneficiation, the Bureau of Mines is conducting research on the flocculation of mineral fines. This paper presents results of studies using crosslinked starches containing carboxyl, diethanolamine, iminodiacetic acid, and xanthate groups to flocculate hematite, goethite, chromite, manganite, pyrolusite, cuprite, and cassiterite fines. The carboxyl and xanthate derivatives flocculated all minerals except cassiterite; the latter was flocculated by only the diethanolamine derivative. The iminodiacetic acid derivative flocculated hematite, goethite, chromite, cuprite, and pyrolusite fines. Zeta potential measurements were made to help define the reaction mechanism responsible for flocculation. The measurements indicate that electrostatic attraction probably is not involved, except possibly in the case of the diethanolamine derivative. The separation of hematite from quartz by selective flocculation with chelating crosslinked starches under two pH conditions and with two dispersing agents is described. Best recoveries and grades were found when either the carboxyl or xanthate derivatives was added at the natural pH of the pulp in the absence of a dispersing agent.

OP 25-83. Control of Diesel Exhaust Emissions in Underground Coal Mines—Single-Cylinder Engine Optimization for Water-in-Fuel Microemulsions, by T. J. Callahan, T. W. Ryan III, G. B. O'Neal, and R. W. Waytulonis. (Proc. SAE Int. Cong. and Exposition on Alternate Fuels for Spark Ignition and Diesel Engines, Detroit, MI, Feb. 28-Mar. 4, 1983.) SEA Tech. Paper Series 830553, 1983, pp. 55-66. The increased use of diesel-powered equipment in underground mines has prompted interest in reducing their exhaust pollutants. Control of particulate emissions without substantial penalties in other emissions or fuel consumption is necessary. This paper describes test results on a prechamber, naturally aspirated, four-cycle diesel engine in which two different concentrations of water-in-fuel emulsions were run. The independent variables comprising the test matrix were fuel, speed, load, injection timing, injection rate, and compression ratio. The dependent variables of the experiment included particulate and gaseous emissions and engine thermal efficiency. Regression analysis was performed on the data to determine how particulate emissions were affected by fuel and engine parameters. Results of this analysis indicated that substantial reductions in particulate emissions could be obtained by utilizing water-in-fuel emissions.

OP 26-83. Bench-Scale Studies To Recover Alumina From Clay by a Hydrochloric Acid Process, by J. A. Eisele, D. J. Bauer, and D. E. Shanks. Ind. Eng. Chem. Prod. Res. Dev., v. 22, No. 1, 1983, pp. 105-110. As part of its goal of producing cell-grade

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alumina from clay, the Bureau of Mines conducted bench-scale cyclic tests of the Bureau's proposed clay-HCl leaching-HCl sparging process and investigated in detail the crystallization of aluminum chloride hexahydrate. The composition of recycled leaching liquor was determined for two HCl sparging crystallization conditions: 36% HCl and 26% HCl. Crystallization research showed that cell-grade alumina could not be produced without a recrystallization step.

OP 27-83. Producing Lead Metal From Lead Chloride in a 3,000-Ampere Cell, by C. H. Elges, M. M. Wong, and R. G. Sandberg. Paper in *Chloride Electrometall.*, ed. by P. D. Parker (Symp., TMS-AIME 111th Annu. Meeting, Dallas, TX, Feb. 15-16, 1982). The Metall. Soc., AIME, 1982, pp. 89-100. The Bureau of Mines, under a cost-sharing, cooperative research program with lead producers, is studying a process to eliminate sulfur oxide generation and to minimize lead emissions in the production of lead metal. The new process consists of leaching lead sulfide concentrate with a ferric chloride-brine solution to produce lead chloride, which is then converted to lead metal by fused-salt electrolysis. For 18 months the Bureau operated an integrated process investigation unit, including both leaching and electrolysis sections, which was designed to treat 750 lb of concentrate and to produce 500 lb of lead metal per day. Electrowinning of lead metal is accomplished in a 3,000-amp fused-salt cell at 450° C, utilizing a LiCl-KCl-PbCl₂ electrolyte. This paper describes the development, construction, and operation of this 3,000-amp cell.

OP 28-83. Beneficiation of Florida Dolomitic Phosphate Ores, by T. O. Llewellyn, B. E. Davis, and G. V. Sullivan. Pres. at SME-AIME Annu. Meeting, Atlanta, GA, Mar. 6-10, 1983. Soc. Min. Eng. AIME preprint 83-10, 7 pp. The Bureau of Mines conducted studies to recover phosphate from four dolomitic southern Florida deposits not currently mined. The samples contained 5.8 to 10.2 percent P₂O₅ and 1.7 to 4.8 percent MgO. Chemical analyses of sized fractions indicated that no pebble concentrate (plus 1.2 mm) could be produced from these samples. A scheme was developed that consisted of desliming, grinding, scrubbing, and redensliming the ore to produce a flotation feed. Conventional one-step fatty acid-fuel oil batch flotation tests on the samples resulted in concentrates containing 29.0 to 31.3 percent P₂O₅ at flotation recoveries ranging from 72.4 to 96.1 percent of the flotation feed. The MgO content of the concentrates ranged from 0.47 to 1.36 percent. Continuous flotation of the Manatee No. 2 sample indicated that commercial-grade phosphate concentrates analyzing 31.3 percent P₂O₅ and 0.55 percent MgO could be produced with a flotation recovery of 89.9 percent. The MgO content of concentrates obtained from the Manatee No. 1 and Hardee samples was 1.20 to 1.36 percent, respectively. Leaching with aqueous SO₂ reduced the MgO content of these phosphate concentrates to 0.5 and 0.8 percent, but with a concomitant loss in phosphate recovery.

OP 29-83. Fluidized-Bed Decomposition of Aluminum Chloride Hexahydrate, by E. Miller, G. E. Call, P. R. Haskett, and L. J. Nicks. Pres. at 112th TMS-AIME Annu. Meeting, Atlanta, GA, Mar. 6-10, 1982. Paper in *Light Metals 1983*, ed. by E. M. Adkins, The Metall. Soc., AIME, pp. 253-271. As part of an investigation by the Bureau of Mines of methods for recovering alumina from domestic non-bauxitic resources, aluminum chloride hexahydrate (ACH) crystals are decomposed in two dense fluid-

ized-bed reactors in series. In the first reactor, ACH is fluidized by the gases of decomposition (HCl and H₂O) produced by indirect heating of the bed and by steam. Concentrated hydrochloric acid may be recovered for use in the process. Partially decomposed solids enter a second fluidized-bed reactor for completion of the decomposition to cell-grade alumina by direct heating with combustion gases. Results from the first-stage decomposition step in a 4-in cylindrical glass reactor and in a tubular bundle reactor are reported. Test conditions included a fluidization face velocity of 0.4 m/sec, space times of 30 min or longer, heating indirectly to temperatures of 190° to 375° C, and gas compositions of 0 to 43 mol-pct HCl and 100 to 57 mol-pct steam. The direct-heated second-stage reactor, a 4-in alloy cylinder, was operated at a fluidization range of 600° to 1,005° C, and with furnace gases containing steam and oxygen of 17.4 to 57.8 total vol-pct. The product is composed of coarser particles than are normally used in an alumina reduction cell, and contains 0.1 pct chloride, which is not present in Bayer alumina.

OP 30-83. Prereduction and Smelting of Domestic (U.S.) Chromites From Montana and California, by R. H. Nafziger, P. E. Sanker, J. E. Tress, and R. A. McCune. *Ironmaking and Steelmaking*, v. 9, No. 6, 1982, pp. 267-277. Four chromites from mines in Montana and California were prereduced to provide suitable charge material for the production of ferrochromium in an electric arc furnace. A part of the Bureau of Mines program investigating technology for efficient and economic recovery of metals from domestic resources, this study has shown that prereduction of these chromites increases productivity and decreases electrical-energy consumption with respect to cases when unreduced materials were used. About 75% chromium metallization and 75% total metallization were realized when high-iron chromites from Montana were prereduced with coal char and coke breeze in a batch rotary kiln. Chromium and total metallizations near 95% were obtained when a metallurgical-grade chromite was prereduced. Satisfactory ferrochromium for the production of stainless steel was produced in an electric arc furnace from all the prereduced materials.

OP 31-83. Control of Diesel Exhaust Emissions in Underground Coal Mines—Steady-State and Transient Engine Tests With a Five Percent Water-in-Fuel Microemulsion, by Glenn B. O'Neal, H. E. Dietzmann, T. W. Ryan III, and R. W. Waytulonis. (Proc. SAE Int. Cong. and Exposition on Alternate Fuels for Spark Ignition and Diesel Engines, Detroit, MI, Feb. 28-Mar. 4, 1983). SAE Tech. Paper Series 830555, 1983, pp. 77-83. This paper is the fourth in a series describing work sponsored by the Bureau of Mines to reduce diesel particulate and gaseous emissions through fuel modification. A stabilized water microemulsion fuel developed in previous work was tested in a Caterpillar 3304 NA four-cylinder engine with compression ratio and injection timing and rate optimized for this fuel to demonstrate the emissions reductions achieved. It was tested in both standard and optimum configurations with both baseline DF-2 and optimized microemulsion fuels. Gaseous and particulate data are presented from steady-state tests using a computer-operated minidilution tunnel and from transient tests using a total exhaust dilution tunnel. The optimized engine-fuel combination was effective in reducing particulates and oxides of nitrogen in steady-state tests. However, the standard engine-fuel combination provided the lowest particulate and NO_x emissions in transient tests.

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- OP 32-83. Dewatering of Fine Particle Clay Waste Using a Flocculant**, by B. J. Scheiner and Annie G. Smelley. Pres. at SME-AIME Annu. Meeting, Atlanta, GA, Mar. 6-10, 1983. Soc. Min. Eng. AIME preprint 83-2, 10 pp. The Bureau of Mines is conducting research on a dewatering technique for fine particles generated during the mineral beneficiation process that will recover a portion of the water now being lost using conventional waste disposal methods and significantly reduce the time required for land reclamation. The technique utilizes a flocculant, polyethylene oxide (PEO), that forms strong stable flocs that can be dewatered rapidly on static and/or rotary screens. In field tests, phosphate clay waste has been dewatered from a nominal 2.5 percent solids to greater than 20 percent solids. In other field tests, coal-clay waste has been dewatered from a nominal 3 percent solids to greater than 55 percent solids. In addition, small-scale continuous tests have shown that bentonitic clays can be dewatered from 12 percent solids to 40 percent solids.
- OP 33-83. A Large-Scale Impact Spalling Test**, by R. Blickensderfer and J. H. Tylczak. Wear, Elsevier Sequoia, the Netherlands, v. 84, No. 3, Feb. 1, 1983, pp. 361-373. A unique test apparatus is described that effectively produces spalling on wear-resistant alloys and can be used to study the causes of spalling. The work was conducted by the Bureau of Mines as part of an effort to minimize the consumption of strategic materials used during the mining and processing of minerals. The test utilizes balls 75 mm in diameter made of the test alloys, which are dropped a distance of 3.5 m. Multiple impacts over a range of energy are produced between the balls. The unique design of the test apparatus provides a multiplying effect that results in 30,000 or more total impacts per hour on 20 or so test alloys. The four major types of failure that were observed on 22 commercial and experimental alloys that received up to 300,000 impacts are discussed.
- OP 34-83. Arizona's Artillery Peak Manganese Deposits**, by Peter G. Chamberlain. Pres. at SME-AIME Fall Meeting and Exhibit, Denver, CO, Nov. 18-20, 1981. Soc. Min. Eng. AIME preprint 81-367, 8 pp. The Bureau of Mines is conducting research to boost domestic production of manganese. Virtually no mining exists in the low-grade and/or small deposits that occur in this country. One large, low-grade manganese deposit located in west-central Arizona—the Artillery Peak district—was extensively studied and sporadically mined during the 1940's and 1950's. Although manganese mining in the district has been long dormant, recent studies indicate that the deposits may be amenable to economical production by heap and/or in situ leaching methods. A conceptual design for an in situ leaching system features undercutting and blasting a block of ore, leaching with SO_2 , and extracting the manganese as a sulfate or oxide. Possible applications to other manganese deposits depend upon formation permeability and specific manganese mineralogy.
- OP 35-83. Stability Evaluation of Retreating Longwall Chain Pillars With Regressive Integrity Factors**, by Paul H. Lu. Proc. 5th Cong. of the Int. Soc. for Rock Mech., Melbourne, Australia, Apr. 10-15, 1983, v. 2, pp. E37-E40. Profiles of mining-induced loading and residual strength across a pillar vary with the position of the longwall face. The residual pillar-strength profile can be constructed on the basis of laboratory-determined triaxial compressive strength, in which the in situ measured horizontal

pressure is considered as the constraint. The vertical-loading profile can be established with the measured vertical pressures. Vertical and horizontal pillar pressures can be measured with hydraulic borehole pressure cells. Defined as the ratio of the integrated total strength to the integrated total load under the profiles, the integrity factor is proposed here as a rational parameter for evaluating chain-pillar stability.

- OP 36-83. Simplest Formula of Copper Iodide: A Stoichiometry Experiment**, by D. J. MacDonald. J. Chem. Educ., v. 60, No. 2, Feb. 1983, p. 147. An experiment suitable for use in teaching principles of stoichiometry and chemical laboratory techniques is described. It is intended for high school or college courses in general chemistry. The experiment involves dissolving a known mass of copper metal and quantitatively precipitating the copper as copper iodide, CuI . A student using the experiment is given as background information the atomic masses of copper and iodine and is expected to determine the empirical formula of copper iodide, that is, to decide from his or her measurement of its I:Cu atom ratio whether copper iodide is CuI or CuI_2 . In use by a group of typical students at the University of Nevada at Reno, the experiment gave an average result for the I:Cu ratio equal to 1.02 with a standard deviation of 0.16.

- OP 37-83. Electric Arc Furnace Melting of Simulated Transuranic Wastes**, by R. H. Nafziger and L. L. Oden. Pres. at 6th Int. Symp. on the Scientific Basis for Nuclear Waste Management, Boston, MA, Nov. 1-4, 1982; Mat. Res. Soc. Symp. Proc., v. 15, 1983. Elsevier Scientific Publishing Co., Amsterdam, the Netherlands, pp. 639-646. As part of an interagency agreement between the Bureau of Mines, U.S. Department of the Interior, and the U.S. Department of Energy through its contractor, EG&G Idaho, Inc., the Bureau conducted six melting tests at its Albany Research Center to assess the feasibility of melting transuranic-containing wastes. The tests were conducted with simulated wastes in a conventional refractory-lined electric arc furnace. Charge materials included concrete, soil, metal, wood, CaO - and Na_2O -containing waste sludges, cement, and polyethylene mixed in various proportions in both unburned and partially incinerated forms. The investigation showed that it is possible to melt these materials in a 1-metric-ton conventional electric arc furnace and separate the slag and metal provided that suitable fluxes are added to condition the siliceous slags. However, the electric arc furnace cannot be considered an efficient incinerator. The molten slags were poured into 210-liter steel drums having a 0.64-cm-thick steel chill plate on the bottom. All slags were tapped from the furnace satisfactorily. The concrete and sludge materials required the most energy for melting. The highest electrode consumption occurred when the sludges were melted. A high alumina-chrome refractory is satisfactory for use as a furnace lining in melting these wastes. Offgases and particulates from all of the tests were sampled and analyzed. The greatest amounts of particulate matter in the offgas streams were obtained from melting sludges and incinerated wastes.

- OP 38-83. The Effect of Ion-Implanted Alloy Additions on the Linear Polarization and Corrosion Fatigue Behavior of Steel**, by B. D. Sartwell, R. P. Walters, N. S. Wheeler, and C. R. Brown. Paper in Corrosion of Metals Processed by Directed Energy Beams, ed. by C. R. Clayton and C. M. Preece (Proc. TMS-AIME Fall Meeting, cosponsored by The Metall.

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Soc. of AIME and Mater. Sci. Div. of ASM, Louisville, KY, Oct. 13, 1981). Metall. Soc. AIME, December 1982, pp. 53-73. As part of the research to determine substitute alloying elements, investigations have been conducted by the Bureau of Mines to determine the effects of different alloying elements, introduced into the substrate by ion implantation, on the corrosion and oxidation behavior of steel. This investigation involved using the three-point linear polarization test to determine the effects of lead and titanium implantation on the aqueous corrosion behavior of iron in a dilute sulfuric acid solution. This technique proved to be a quick, accurate corrosion rate test suitable for evaluating the ion-implanted alloys so that an assessment could be made of the effects of the specific alloy additions on corrosion behavior.

OP 39-83. Filtration of Asbestos and Other Solids With Magnesium Oxide, by J. E. Schiller and S. E. Khalafalla. Pres. at SME-AIME Annu. Meeting, Las Vegas, NV, Feb. 24, 1980. Soc. Min. Eng. AIME preprint 80-108, Mar. 1983, pp. 237-242. Owing to its unique surface properties, magnesium oxide (MgO) is an excellent medium to filter asbestos and other suspended solids from water. MgO operates up to twice as long as a sand filter before backwashing is required while flow rate and filtrate clarity are as good or better with MgO.

OP 40-83. Energy Recovery Using Hydraulic Turbines in Deep Underground Mines, by R. N. Torbin and E. D. Thimons. Mech. Eng., v. 105, No. 4, Apr. 1983, pp. 57-61. Mines in the United States are continually descending to greater depths in the search for minable deposits, but the high temperatures and humidities encountered at these depths make a comfortable working environment difficult and expensive to maintain. To help deal with this problem, the Bureau of Mines awarded a contract to investigate and evaluate commercially available means of energy recovery for the deep mining industry. This paper discusses benefits that can be realized using high-pressure water to operate a turbine, the economic considerations, the use of turbine technology in mine applications, and outlines the research program plan for further study.

OP 41-83. Size and Shape Characteristics of Amphibole Asbestos (Amosite) and Amphibole Cleavage Fragments (Actinolite, Cummingtonite) Collected on Occupational Air Monitoring Filters, by Robert L. Virta, Kim B. Shedd, Ann G. Wylie, and Janet G. Snyder. Ch. 47 in *Aerosols in the Mining and Industrial Work Environments. Volume 2. Characterization*, ed. by V. A. Marple and B. Y. H. Liu. Ann Arbor Sci. Pub., Ann Arbor MI, Mar. 1983, pp. 633-643. The objective of this study by the Bureau of Mines was to determine if particle populations from asbestiform and nonasbestiform mineral sources can be distinguished through least-squares regression analyses using the relationship:

$$\log_{10} \text{width} = F \log_{10} \text{length} + b$$

where F = fibrosity index, the slope of the regression line

b = intercept on the \log_{10} width axis

Amphibole particles on air monitoring filters from three mining and two industrial sites were characterized by scanning electron microscopy and energy-dispersive X-ray spectroscopy analysis. The data are evaluated using particle length and width summary statistics and compared with analyses by linear regression. Conclusions based on comparison of data manipulation using these two techniques follow: The mining site particle populations are morphologically similar, the industrial site particle

populations are morphologically similar, and size and shape characteristics of mining site populations are statistically different from those of the industrial sites. Determination of either an asbestos or a nonasbestos source of amphiboles using linear regression techniques on data obtained from examination of air monitoring filters is a potential application of this technique.

OP 42-83. Adhesion and Hardness of Platinum Coatings Electrodeposited From Molten Salts, by R. P. Walters, M. J. Lynch, and D. R. Flinn. *Plat. and Surface Finishing J.*, v. 70, No. 5, May 1983, pp. 91-95. Utilizing a direct pull solder method, the adhesion of platinum coatings to TZM and Fe10Cr substrates was determined. The average fracture value was 331 MPa (48,000 lb/in²), with fracture occurring in the substrate or in some combination of the substrate, coating, and solder, but not at the deposit-substrate interface, indicating that the true adhesion of the coatings is greater than the measured fracture values. Cross-sectional hardness values were dependent on the average grain width, with hardness values ranging from 52 to 120 HK_{0.05} at 35 and 8 μm , respectively, from the substrate-coating interface.

OP 43-83. Geologic Estimates and Future Costs of Strip Mining Coal, by Emil D. Attanasi and Eric K. Green. *Energy Systems and Policy J.*, v. 6, No. 3, 1982, pp. 193-212. Geologic coal-resource appraisals, which typically describe the location and general characteristics of coalbeds, do not generally provide enough information to estimate the cost of developing the resource or to predict the escalation of costs expected to result from physical depletion. This paper considers the nature of data and methods of appraisal required to provide this cost information to policymakers. Illinois is used as a prototype area for analysis because of its long history of coal mining and its demonstrated coal reserve base of strippable coal that exceeds all but two of the States in the United States. Evidence of gradual depletion of Illinois strippable coal reserves is provided by declining labor productivity, decreasing average mine size, and increasing overburden depth. The procedures used to estimate the costs of mining remaining deposits indicate that the physical characteristics that will affect mining costs most significantly are depth of overburden, thickness of coal seam, and areal extent of coal of the minable reserve blocks. Findings presented here provide guidelines for the collection of economic and geologic data in order to improve coal appraisals, particularly those currently in progress in the Western United States.

OP 44-83. Infrared Temperatures of Coal Dust Explosions, by Kenneth L. Cashdollar and Martin Hertzberg. *Combust. and Flame*, v. 51, 1983, pp. 23-35. A comprehensive set of temperature measurements is presented for coal dust explosions as a function of dust concentration. Data include the dependence of explosion temperature on particle size, volatility, oxygen content, and added rock dust. The majority of the data are for constant volume explosions in a laboratory-scale vessel, but data from a coal dust burner flame and full-scale mine dust explosions are also included. In all of the measurements, the gas temperature was significantly higher than the dust particle temperature. The measurements were made with a three-wavelength near-infrared pyrometer and a six-wavelength infrared pyrometer (in the 1 to 5- μm -wavelength region). Some thermocouple measurements are shown for comparison.

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OP 45-83. Using the U.S. Bureau of Mines Minerals Availability System for Supply-Demand Analysis,

by Eric Green and James Grichar. *Mater. and Soc.*, v. 6, No. 4, 1982, pp. 471-482. In recent years numerous attempts have been made to model non-fuel minerals markets and forecast trends in price, demand, supply, import reliance, etc. On the supply side, econometric models based on historical data were constructed with less than satisfactory results. Such models and their estimates of the future primary supply of nonfuel minerals may be more accurate if the physical characteristics of the known deposits are evaluated using standardized engineering-cost methodology. The Minerals Availability System (MAS) of the U.S. Bureau of Mines transforms this type of deposit information into estimates of potential nonfuel minerals production. MAS estimates potential production from domestic and foreign deposits; this will be done for 34 commodities. This paper shows how MAS can be used in partial equilibrium analysis of the copper market. In particular, a domestic primary supply function is developed based on MAS data; this and other models are then used to predict equilibrium price and quantity under various assumptions.

OP 46-83. Domains of Flammability and Thermal Ignitability for Pulverized Coals and Other Dusts: Particle Size Dependences and Microscopic Residue Analyses,

by Martin Hertzberg, Kenneth L. Cashdollar, Daniel L. Ng, and Ronald S. Conti. Paper in Nineteenth Symposium (International) on Combustion (Haifa, Israel, Aug. 8-13, 1982). *Combustion Inst.*, Pittsburgh, PA, 1982, pp. 1169-1180. New data presented for the particle size dependence of the domains of flammability and thermal ignitability for two bituminous coal dusts and for polyethylene powder showed that below some threshold or characteristic diameter, the behavior of all the dusts was independent of particle size and approached that of an equivalent premixed gas. Above the characteristic diameter, the lean limit of flammability and the minimum autoignition temperature increased with increasing particle size. For still larger particle sizes, a critical diameter was reached, above which the dusts were nonexplosive at ambient temperature. Both the characteristic diameter at which a size dependence first appears and the critical diameter above which the dust is nonexplosive increase monotonically with increasing volatility of the dust. The characteristic diameter and critical diameter also increase monotonically with increasing ambient temperature and with increasing oxygen content of the dispersing gas.

OP 47-83. Supply Prospects for the U.S. Copper Industry: Alternative Scenarios: Midas II Computer Model,

by W. R. Hibbard, Jr., H. D. Sherali, A. L. Soyster, and L. J. Sousa. *Mater. and Soc.*, v. 6, No. 2, 1982, pp. 201-210. The Midas II linear programming model of the U.S. copper industry was revised to reflect conditions resulting from the 1980-81 recession, the high cost of money, and reduced demand. Various scenarios were run to evaluate the impact of tax reductions, high rates of economic growth, severance tax, and changes in pollution control requirements on copper demand, supply, and price. The most stimulating effects resulted from high demand generated by an increased rate of economic growth. The next most stimulating effects resulted from a 20% tax cut together with no pollution control costs. The tax cut alone caused little change from the base case. The most devastating effects resulted from requiring an 18% rate of return combined with an Intergovernmental Council

of Copper-Exporting Countries embargo. The 18% rate of return reduced U.S. production that was made up from imports. When the imports were not available, the impact was drastic. The model seemed to perform appropriately under the circumstances prescribed.

OP 48-83. Mining, by Barry W. Klein and Ronald F. Balazik. Ch. 15 in *U.S. Ind. Outlook*

1982, pp. 147-150. Mining production is expected to increase in 1982, as was the expectation for 1981. Tax law changes should encourage investment, and a new cabinet-level council is addressing mineral industry issues and problems. Improvement will be gradual, however, because changes in Government policy do not have immediate effects. This paper covers SIC codes 10 and 14, nonfuel metallic and nonmetallic minerals. SIC code 10 includes ores of such metals as iron, copper, lead, zinc, and molybdenum. SIC code 14 includes both nonmetallics, such as stone, sand and gravel, and clays, and chemical minerals such as phosphate rock, potash, and sulfur.

OP 49-83. Mining, by Barry W. Klein, Annette P. Graham, and Anthony Oprychal. Ch. 16

in *U.S. Ind. Outlook* 1983, pp. 16-1-16-7. Mining production is expected to increase somewhat in 1983 compared with the relatively low levels in 1982. This anticipated improvement reflects the upturn in the economy forecast for 1983. In April 1982, the President submitted to Congress the National Materials and Minerals Program Plan and Report, which recognizes the vital importance of minerals to the economy and national security. This paper covers SIC codes 10 and 14, metallic and nonmetallic mineral industries, excluding fuels. SIC code 10 includes ores of such metals as iron, copper, gold, molybdenum, and lead. SIC code 14 includes nonmetallics, such as stone, sand and gravel, and clays; and chemical minerals such as phosphate rock, sulfur, salt, and potash.

OP 50-83. The Vapor-Liquid Equilibria of the Aluminum Chloride-Ferric Chloride System, by H. C. Ko,

A. Landsberg, and Jack L. Henry. *Metall. Trans. B*, v. 14B, June 1983, pp. 301-304. Work was undertaken at the Bureau of Mines Albany (OR) Research Center to measure the vapor-liquid equilibria in the aluminum chloride-iron chloride system at realistic pressures. The equilibrium diagram constructed from these data can be used to evaluate the possibility of using distillation for separating iron chloride from aluminum chloride. This work is part of a larger effort to study the carbochlorination of domestic clay as a means to produce anhydrous aluminum chloride for reduction in the more energy-efficient chlorine cell.

OP 51-83. Iodine, by P. A. Lyday. *Min. Eng.*, v. 35, No. 5, May 1983, p. 495. In 1982,

U.S. iodine demand decreased as the economy remained depressed and iodine prices remained high. Demand decreased 9% to about 36 kt (3,950 st) valued at \$48 million. Imports from Japan (81%) and Chile (18%) were the major source of U.S. supply. Two U.S. companies produced at 1981 levels and supplied about 25% of domestic demand. Demand is expected to increase during 1983.

OP 52-83. Feasibility of In Situ Leaching of Metallic Ores Other Than Copper and Uranium, by George

M. Potter, Clement K. Chase, and Peter G. Chamberlain. Pres. at 2d SME-SPE Int. Symp. on Solution Mining, Denver, CO, Nov. 18-20, 1981, SME preprint 81-363, 6 pp.; pub. in *Interfacing Tech-*

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nologies in *Solution Mining*, ed. by W. J. Schlitt and J. B. Hiskey. Soc. Min. Eng. AIME, Littleton, CO, 1982, pp. 123-130. Under contractual arrangements with the Bureau of Mines, Mountain States Research and Development, Inc., completed a technological investigation to determine the feasibility of in situ mining of metal commodities other than copper and uranium. The study was based upon available literature and experience. The selection of potential candidates for in situ mining was influenced by economic importance, probable amenability to in situ methods, and environmental considerations. Four metals (or metal pairs) were chosen for feasibility studies: aluminum (with a copper byproduct), gold-silver, and manganese were recommended for further study and action; cobalt-nickel was also recommended contingent upon preliminary laboratory leaching and recovery investigations and field geohydrological work. Mining and recovery plans and an economic evaluation are included. Other metals with potential for in situ leaching are lead-zinc, molybdenum, and vanadium.

OP 53-83. Strategic Planning in the Minerals and Materials Industries in an International Era, by Louis J. Sousa. *Mater. and Soc.*, v. 7, No. 1, 1983, pp. 49-50. Strategic planning is a process in which a firm attempts to clearly define what it is trying to achieve and to identify the optimal paths for achieving these objectives. Materials firms recently have come to place more attention on strategic planning. Foreign competition has increased significantly. For most of the major metals, a slow growth future seems to be in the offing. Strategic planning can provide materials firms with a better understanding of the change that is occurring so rapidly. It can enable a firm to better control as it maneuvers towards the most profitable directions.

OP 54-83. Iron Oxide Pigments, by W. I. Spinrad, Jr. *Min. Eng.*, v. 35, No. 5, May 1983, pp. 495-496. U.S. mine production and shipments of crude iron oxide pigments and finished iron oxide shipments and U.S. imports decreased markedly in 1982 compared with 1981 levels. U.S. exports over the same period increased sharply. Decreases in demand for iron oxide pigments have been caused by curtailed consumption and inventory reduction by most domestic consumers of these pigments.

OP 55-83. State Severance Taxes: An Analysis of the Impact of Rate Changes on Copper Recovery Costs, by Phillip N. Yasnowsky and Annette P. Graham. *Mater. and Soc.*, v. 6, No. 2, 1982, pp. 233-246. This paper uses the Bureau of Mines Minerals Availability System to analyze the possible effect of assumed State severance tax rate changes on copper recovery costs. For a comprehensive background study of severance taxes, the reader is referred to the Bureau's Information Circular 8788.

OP 56-83. Strontium, by J. E. Ferrell. *Min. Eng.*, v. 35, No. 5, May 1983, pp. 510-511. The United States continued as the world's largest producer and consumer of strontium compounds, even though there has been no domestic mining of strontium ores since 1959. Imports dropped sharply for strontium minerals (celestite) from 45 kt (49,699 st) in 1981 to 30 kt (33,075 st) in 1982—the lowest annual tonnage since 1975. More than 99% of the celestite came from Mexico. Strontium compound imports also declined from the 1981 level by about 32% to 1.8 kt (1,942 st).

OP 57-83. Quartz Crystal, by W. Johnson. *Min. Eng.*, v. 35, No. 5, May 1983, p. 506. Industrial quartz crystal continues to be of critical importance to the electronics industry. It is used extensively for military and civilian communications networks requiring precise frequency control, oscillator watches, and numerous other timing devices including automobile microprocessors. Only a minute amount of quartz crystal is used for optical purposes.

OP 58-83. Bromine, by P. A. Lyday. *Min. Eng.*, v. 35, No. 5, May 1983, pp. 487-488. The article is an overview of the bromine industry during 1982. The United States continued to be the largest producer of bromine in the world. Ethylene dibromide, used as a lead scavenger in gasoline, was the largest area of demand. Sections discuss U.S. development, foreign developments, and outlook for the future of the industry.

OP 59-83. An Econometric Model of the Short-Run Demand for Workers and Hours in the U.S. Auto Industry, by Julius C. Chang. *J. Econometrics*, Elsevier Science Publishers B.V., North-Holland, v. 22, No. 3, August 1982, pp. 301-316. Based on the labor hoarding theory and the Koyck-type adjustment mechanism, a model of the short-run demand for workers and hours in the U.S. auto industry is developed and estimated using Michigan and U.S. data, respectively. Statistical tests of the model structure are then conducted to confirm the theoretical specifications.

OP 60-83. Recovery of Lead From Battery Sludge by Electrowinning, by E. R. Cole, A. Y. Lee, and D. L. Paulson. *J. Met.*, v. 35, No. 8, August 1983, pp. 42-46. Research by the Bureau of Mines has resulted in a combination electrorefining-electrowinning method for recycling the lead from scrap batteries. The lead metal grids and lugs are separated from the sludge by ball milling, washing, and screening and are melted and cast into anodes for electrorefining by the Betts process using waste fluosilicic acid as the electrolyte. The Betts process, established in commercial use for 80 years, has been well described in the literature and needs no further description here. The sulfate-oxide-metal sludge remaining after separation of the lead metal is treated in a two-step leaching operation with ammonium carbonate, waste fluosilicic acid, and Pb powder to solubilize the lead for recovery by electrowinning. Unlike electrorefining, electrowinning is not being practiced commercially now. Prior attempts to electrowin lead have failed because large quantities of insoluble lead dioxide are deposited on the anodes at the expense of lead deposition on the cathodes. This paper describes bench-scale research for recovering lead from battery sludge by electrowinning that prevents PbO₂ formation at the anodes. The bench-scale work has been successfully completed, and electrowinning experiments are presently being conducted in a 20-liter multielectrode cell.

OP 61-83. Survival Kits for the Breath of Life, by Nicholas Kyriazi. *Footprints*, v. 46, No. 1, June 1983, pp. 18-23. This is a brief discussion of some of the equipment being developed by the U.S. Bureau of Mines to improve the odds for the survival of miners exiting an underground coal mine after an emergency and to enhance the safety of rescue

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team members recovering the mine. At a lay worker's technical level, a new escape breathing apparatus, a low-profile rescue breathing apparatus, a mine rescue team protective ensemble, and a rescue team helmet are presented with appropriate background information describing their need and operation.

OP 62-83. Thermal Degradation of Oil Shale With Molten Nitrates, by Yael Miron. *Thermochim. Acta*, Elsevier Science Publishers, B.V., Amsterdam, the Netherlands, v. 65, 1983, pp. 213-237.

The present study was conducted at the Bureau of Mines to explore the effect of a variety of molten nitrate salts on the thermal decomposition of one oil shale sample from the Green River Formation. Thermal analysis, coupled with effluent gas analysis, was used for all the tests in which the samples were heated at a constant heating rate. Weight losses of heated oil shale in the presence of nitrates were found to be higher than similar losses in the absence of nitrates. Ammonium nitrate degraded the oil shale at a lower temperature than that at which oil shale started to decompose when heated by itself, or in the presence of sodium nitrate or potassium nitrate. From scanning electron microscopy of the heated oil shale samples, it appears that ammonium nitrate attacked both the inorganic and the organic portions of the shale. These results indicate that a more detailed investigation of the effects of ammonium nitrate, and perhaps other nitrates, on fuel recovery from oil shale will be a worthwhile undertaking.

OP 63-83. How To Design Cabs and Canopies. Part I—Measuring the Problems, by William W. Aljoe. *Coal Min. & Proc.*, March 1983, pp. 61-67.

This is the first of a series of three articles. The purpose of the series is to describe the results of approximately 3 years of research, sponsored by the Bureau of Mines, to document the application of cabs and canopies in low coal mines. This article describes a procedure to define the minimum and practical working heights at which canopies can be used without roofing and without restricting operator comfort or vision.

OP 64-83. How To Design Cabs and Canopies. Part II—Increasing Comfort and Vision, by William W. Aljoe. *Coal Min. & Proc.*, April 1983, pp. 94-118.

This is the second of a series of three articles. The purpose of the series is to describe the results of approximately 3 years of research, sponsored by the Bureau of Mines, to document the application of cabs and canopies in low coal mines. This article examines the problems of operator comfort and vision resulting from the canopies on existing equipment.

OP 65-83. How To Design Cabs and Canopies. Part III—Avoiding and Solving Problems, by William W. Aljoe. *Coal Min. & Proc.*, May 1983, pp. 58-63.

This is the third of a series of three articles. The purpose of the series is to describe the results of approximately 3 years of research, sponsored by the Bureau of Mines, to document the application of cabs and canopies in low coal mines. This article discusses how optimum machine selection, changes in mine operating procedures, and improvements in cab and canopy design can help solve canopy-related problems inherent to low coal mines.

OP 66-83. Heat Capacities of Titanium Disulfide From 5.87 to 300.7 K, by Richard P. Beyer. *J. Chem. & Eng. Data*, July 1983, pp. 347-348.

The heat capacity of TiS_2 was determined from 5.87 to 300.7 K by adiabatic calorimetry. The values at 298.5 K for C_p° , $S^\circ(T) - S^\circ(O)$, $-[G^\circ(T) - H^\circ(O)]/T$, and $H^\circ(T) - H^\circ(O)$ are 67.34, 78.21, 36.89 J mol⁻¹ K⁻¹, and 12.38 kJ mol⁻¹, respectively.

OP 67-83. Noise Control of an Underground Mine Personnel Carrier, by Anthony G. Galaitis and Thomas G. Bobick. *Noise Contr. Eng. J.*, v. 21, No. 1, July-August 1983, pp. 4-9.

The interior noise of a mine-operated rail personnel carrier was reduced by replacing some standard components with acoustically treated components. The latter included a softer suspension, softer motor mounts, damped panels, sound-absorbing motor enclosures, and helical gears. Depending on operating conditions, the modified vehicle was 6 to 7.5 dBA quieter than an unquieted vehicle. The noise level in the vehicle interior was reduced to approximately 85 dBA at an average vehicle speed.

OP 68-83. The Oxygen Cost of an Escape From an Underground Coal Mine, by Eliezer Kamon, Diane Doyle, and John Kovac. *Am. Ind. Hyg. Assoc. J.*, v. 44, No. 7, July 1983, pp. 552-555.

Six 27- to 63-year-old coal miners performed an escape maneuver from an underground mine along a passageway that required walking and running erect or stooped, duckwalking, and crawling. The miners traveled at different speeds, for each mode of locomotion. The minute pulmonary ventilation (V_E), uptake (V_{O_2}), and heart rate (HR), recorded continuously on a magnetic tape via lightweight meters carried on the miners' waists, indicated similar average and peak values for all modes of locomotion. The mean V_E , V_{O_2} (L·min⁻¹, STPD), and HR (b·min⁻¹) were, respectively, 49, 1.63, and 143 for the average values, and 52, 1.92, and 161 for the peak values. Compared to the aerobic capacity obtained during graded treadmill test to exhaustion, the average effort of the escape was performed at 64% and the peak effort at 70% of the miners' aerobic capacity for an escape time of 58 minutes.

OP 69-83. Methane in Pennsylvania Coal: An Overview, by Carla A. Kertis, James P. Ulery, and Roger L. King. Ch. 24 in *Pennsylvania Coal: Resources, Technology and Utilization*, ed. by S. K. Majumdar and E. W. Miller. *PA Acad. Sci.*, 1983, pp. 439-461.

The hazards of methane gas have been associated with coal from the inception of underground mining. Methane occurs in the air of most coal mines because when coal was formed from ancient peat swamps, methane was also formed. The common occurrence of methane and its explosibility when mixed with air are directly responsible for numerous mine disasters. Owing to the inherent gassiness of all underground coal mines, various methods of removing methane have been developed. These degasification techniques have improved safety conditions in coal mines while maintaining high production rates and have facilitated the use of a valuable energy resource.

OP 70-83. Interfacing an XRF Spectrometer and Computer System to Aid Data Management, by D. G. Kuehn, D. C. Lundeen, R. L. Brandvig, and R. H. Jefferson. *Am. Lab.*, v. 15, No. 9, September 1983, pp. 16-23.

Data management for X-ray fluorescence spectroscopy can be cumbersome and time-consuming, especially when multielement analyses are required for each sample material. To speed and

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simplify the process while utilizing existing equipment, the Bureau of Mines has interfaced free-standing X-ray fluorescence and computer systems. This report discusses the implementation procedures in terms of both hardware and software requirements.

OP 71-83. Smelting Ferrochromium From a New Guinea Lateritic Chromite, by R. H. Nafziger. *Trans. Inst. Min. Metall. (Sec. C: Miner. Process. Extr. Metall.)*, v. 92, June 1983, pp. C73-C82. The Bureau of Mines cooperated with the NORD Resources Corp. to evaluate the feasibility of smelting a lateritic chromite concentrate from New Guinea to produce ferrochromium by electric arc furnace processing. One series of five tests was conducted in a nominal 100-kg furnace to evaluate slag compositions, carbonaceous reductants, and smelting characteristics of the chromite. A second series of five 1-ton furnace tests was made to obtain such engineering data as energy consumption, melting rates, and bath temperatures. Results showed that a high-carbon ferrochromium can be prepared from the New Guinea lateritic chromite concentrate, although the phosphorus levels were high. Chromium recovery in the ferroalloy with up to 52 wt % chromium averaged nearly 80%. Energy consumption compared favorably with that reported in commercial practice. Submerged arc operations provided the most efficient smelting conditions. On the basis of results obtained in the small-scale batch operations, agglomeration of the charge materials may not be required. Because of the relatively fine size of the chromite concentrate, carbon requirements should include woodchips to improve operation of the furnace. In general, variables for smelting lateritic chromites are similar to those for the production of high-carbon ferrochromium from offgrade chromites.

OP 72-83. Noise Control for Aggregate Plants, by Robert J. Pokora, Terry L. Muldoon, and Thomas G. Bobick. *Pit & Quarry*, September 1983, pp. 40-44. Barrier materials, operator enclosures, and resilient materials were used in a demonstration program for retrofitting aggregate plants for noise reduction. The techniques employed in the program can provide guidelines for designing, installing, and evaluating retrofit noise control systems in crushing and screening plants. This article discusses the details of a survey of the nonmetallic mining industry, the design and installation of retrofit noise control treatments, and the field evaluation of those controls under actual operating conditions.

OP 73-83. Specimen Preparation and Sizing by Image Analysis of Respirable Quartz Particles Collected on Coal Mine Air-Monitoring Filters, by J. G. Snyder and C. W. Huggins. *Proc. 18th Annu. Meeting, Microbeam Anal. Soc. of America, Phoenix, AZ*, Aug. 6-12, 1983; pub. in *Microbeam Analysis—1983*, ed. by R. Gooley, San Francisco Press, Inc., pp. 22-26. Several quartz standards and respirable coal mine dust samples containing significant amounts of quartz were used to develop a method of quartz particle-size determination by image analysis. Data on the quartz particle size are crucial for the accurate determination of quartz in respirable coal mine dusts collected on air-monitoring filters by MSHA. In this study, three pure ground quartz materials were chosen for particle-size distribution measurements: Minusil -5, Minusil -10, and Silver Bond B.

OP 74-83. Hot-Crush Technique for Separation of Cast- and Wrought-Aluminum Alloy Scrap, by Fred Ambrose, R. D. Brown, Jr., Dominic Montagna, and H. V. Makar. *Proc. 4th Recycling World Cong., New Orleans, LA, Apr. 5-7, 1982*; pub. in *Conserv. & Recycling*, v. 6, No. 1/2, 1983, pp. 63-69. A novel technique for the separation of cast and wrought aluminum alloy scrap is described. This technique, developed by the Bureau of Mines, exploits differences in hot ductility between cast and wrought aluminum. Tests are in progress to demonstrate its use for upgrading mixed aluminum scrap into recyclable grades of wrought and cast alloys. This paper describes (1) process development studies using conventional heating, fragmentizing, and screening equipment and (2) process improvements to enhance commercial development.

OP 75-83. New Technique Vacuums Gob Gas. Cross-Measure Boreholes Controlled Longwall Gob Gas at a Bethlehem Mine, by A. A. Campoli, Joseph Cervik, and F. Burns. *Coal Min. Process.*, v. 20, No. 3, March 1983, pp. 48-51. The cross-measure borehole technique is being developed jointly by the Bureau of Mines and Bethlehem Mines Corp. as an alternative to current U.S. longwall methane control techniques. Small-diameter inclined boreholes are drilled from underground locations into roof strata that will be fractured when the longwall panel is removed. Methane contained in the fractured strata is collected in the cross-measure boreholes and drawn through an underground pipeline to a central surface borehole by a vacuum pump.

OP 76-83. Grouting Methane Drainage Holes in Coalbeds, by Joseph Cervik. *Proc. ASCE Spec. Conf. on Grouting in Geotechnical Engineering*, New Orleans, LA, Feb. 10-12, 1982, pp. 651-664. Horizontal drainage holes drilled into gassy coalbeds are effective in reducing methane flows into mine workings during mining operations. Drainage holes were drilled 415 to 2,126 ft (126 to 648 m) long. Holes were sealed with cement before interception by the mining machine to avoid formation of explosive methane-air mixtures. The cement slurry consisted of cement, fly ash, and fluidifier. Excess water was used in the slurry to avoid plugging problems because of the distance the slurry was pumped. When the hole was filled with slurry, pressure was increased to squeeze excess water into the coalbed fracture system. Examination of intercepted drainage holes showed that in some cases, water had separated from the slurry and had not been squeezed into the fracture system. In no case was cement slurry forced into the fracture system. In a subsequent study, water content of the slurry was reduced to recommended quantities. Where water flow from drainage holes before grouting was less than 0.5 gal/min (1.9 L/min), holes were satisfactorily sealed. Water flow greater than 2 gal/min (7.6 L/min) before grouting diluted the slurry and water stratified in the hole. When the hole was intercepted, gas pressure forced water and then methane from the hole. The resulting methane accumulation caused the machine-mounted methane monitor to indicate the high methane accumulation, thus deenergizing electrical power to the mining machine.

OP 77-83. Control of Methane in Gob and Bleeders by the Cross-Measure Borehole Technique, by Joseph Cervik and Roger L. King. *Proc. 14th Annu. Inst.*

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on Coal Mining Health, Safety, and Research, Blacksburg, VA, Aug. 23-25, 1983, pp. 139-148. In Europe and the United Kingdom, small-diameter drainage holes (cross-measure boreholes) are drilled into strata overlying a longwall to control methane in the gob and to prevent it from mixing with the ventilation air. These drainage holes are connected to an underground pipeline that is maintained under a partial vacuum by surface vacuum pumps. Bureau of Mines tests in the Upper Kittanning Coalbed utilizing the cross-measure borehole system demonstrated the capture of 50 pct of the total methane generated by the mining operation. The angle of the hole above horizontal, depth of penetration of the hole into the gob, and location of the pipeline and collar of the hole are important parameters affecting the performance of the cross-measure borehole technique.

OP 78-83. Reverse Performance Characteristics of Main Mine Fans, by M. F. Dunn, F. S. Kendorski, S. Bhattacharya, V. Rajaram, and E. D. Thimons. *Min. Sci. & Technol.*, Elsevier Science Publishers B.V., Amsterdam, the Netherlands, v. 1, No. 1, October 1983, pp. 59-68. During a mine fire or other emergency, it may be desirable to reverse the airflow in order to provide an escapeway or to isolate a fire. Also, in colder areas, the airflow may be reversed to prevent ice buildup. When reversing main mine fans, the mine operator usually does not know what operating characteristics of flow and pressure to expect. Laboratory and field tests of vane axial main mine fans were conducted to establish forward and reverse performance characteristics under controlled conditions and in typical mine installations. All fans tested were between 81 and 96 in (2.1 and 2.4 m) in diameter. The data obtained suggest that reverse performance characteristics are dependent upon the blade angle and the hub-to-tip ratio. There is also evidence that reverse performance can be predicted for a family of blade angles for a given hub-to-tip ratio. Generally fan quantity is 30% to 60% less in reverse than when operating in the normal forward mode, with static pressure equal to the square of the volume percentage change.

OP 79-83. Methane Drainage Experience With Horizontal Boreholes in a Western Coalbed, by Gerald L. Finfinger, John H. Perry, and Roger L. King. *Proc. Australas. Inst. Min. and Metall. Symp. on Seam Drainage With Particular Reference to the Working Seam, Wollongong, NSW, Australia, May 11-14, 1982*, pp. 102-115. The Bureau of Mines in cooperation with Kaiser Steel Corp. conducted two methane drainage studies in an advancing section of the Sunnyside No. 1 Mine where production was being severely hampered by methane emissions. Six horizontal boreholes were completed during the studies to an average length of 291 m. Total gas production from the boreholes as of December 1981 has exceeded 6,088,800 m³. Methane emissions into the section were reduced by 40 pct as a result of the first drainage system. The second drainage system is currently producing 11,328 m³/d from four boreholes. Mining of the section is expected to begin within 2 years.

OP 80-83. Water Removal From Mine Slimes and Sludge Using Direct Current, by D. J. Kelsh and R. H. Sprute. *Drying Technol.*, v. 1, No. 1, April 1983, pp. 57-81. Recent tests by the Bureau of Mines have demonstrated the effectiveness of electrokinetic dewatering to consolidate a variety of coal

and mineral slimes. Material properties and application methods that affect performance are briefly reviewed, and some operating and proposed field installations are described. Application of the method to other slimes and sludges can best be determined through laboratory testing, but certain physical properties can be helpful predictors of responsiveness.

OP 81-83. Methane Drainage: Development of a Large-Scale Field Demonstration Using Vertical Boreholes, by Roger D. King and Michael A. Trevits. *Proc. Australas. Inst. and Metall. Symp. on Seam Drainage With Particular Reference to the Working Seam, Wollongong, NSW, Australia, May 11-14, 1982*, pp. 81-88. The United States Steel Corp. in cooperation with the U.S. Government is conducting a large-scale methane drainage field demonstration using stimulated vertical boreholes drilled in advance of mining. A grid pattern of 23 boreholes, isolating approximately 1.5 km² of coalbed area, was drilled to the lower bench of the Mary Lee Coalbed, Jefferson County, AL. Upon completion of drilling operations, various hydraulic stimulation treatments utilizing nitrogen-generated foam, water, and gelled fluid were performed to enhance the rate of methane gas removal. Production from the grid pattern began in September 1977 and continued as the last borehole was placed on production during October 1980. To date, in excess of 33,800,000 m³ of methane gas has been drained as a result of this effort. Underground mining operations were approximately 3.2 km from the grid pattern when production began and have currently progressed to within 1.6 km. Underground interception of the grid is expected in 1986.

OP 82-83. Computer-Implemented Coalbed Methane Data Base, by John C. LaScola, David M. Hyman, and William P. Diamond. Ch. 29 in *Proc. 1st SME-AIME Conf. on Use of Computers in the Coal Industry, Morgantown, WV, Aug. 1-3, 1983*, pp. 251-257. The U.S. Department of the Interior, Bureau of Mines, has established a computer-implemented coalbed methane data base containing data representing over 2,000 coal samples from approximately 250 coalbeds located in 17 States and 1 Canadian Province. Space for approximately 130 sample characteristics is reserved for each sample record and is divided for access efficiency into three separate physical files. A software package was written to provide a user-friendly environment in which the three files can be manipulated simultaneously. These files can be used interactively in DATATRIEVE 11, a commercially available sorting, retrieval, and report-writing software package, or in any FORTRAN-compatible system for statistical analysis. The data base was established for coalbed methane research in response to the health and safety needs of the mining industry. Possible applications of the data base include mine planning related to the occurrence of gas, as well as delineating areas of resource recovery and utilization.

OP 83-83. Program Computes Radius-of-Curvature Coordinates for Straight, Deviated Holes, by David C. Oyler. *Oil & Gas J.*, v. 81, No. 43, Oct. 24, 1983, pp. 100-108. The Bureau of Mines, U.S. Department of the Interior, has developed a program for the Hewlett-Packard HP-41C(V) that determines the change of position of a drill hole between two survey stations, using the radius-of-curvature calculation method. Values required to perform a single calculation are the bearings, inclinations, and

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measured depth at each station. The program automatically stores the most recent values of bearing, inclination, and measured depth for use in the next survey and automatically updates a set of hole position coordinate values. The program also asks for magnetic declination and project angle values upon initialization so that bearings obtained from magnetic compass data can be automatically corrected for declination and so that a cross section of the hole can be plotted. The program is friendly to the user, prompting for all required data entry and echoing the entered data and all output data with labels. It is also designed to allow correction of data entry mistakes and erasure of surveys calculated from errant data.

OP 84-83. Coal Cutting Research Slashes Dust, by Wallace W. Roepke. *Coal Min. Process.*, v. 20, No. 2, October 1983, pp. 38-44. The Coal-Cutting Technology Group at the Bureau of Mines Twin Cities (MN) Research Center is investigating ways to reduce primary dust generated by coal cutting. The progression of research within the program is from fundamental laboratory research, to fundamental field research, to field concept verification. Then the Bureau recommends warranted changes and/or prototype development to industry. Currently the group has several projects in each phase of research. The Bureau's current fundamental studies of bit characteristics are directed toward determining the effects of conical bit wear on primary respirable dust generation, energy, and cutting forces; establishing best conical bit mount condition to increase life by enhancing bit rotation; and comparing chisel-type cutters to conical-type cutters. Additionally, to establish a suitable homogeneous reference material for cutting experiments, a synthetic coal with a plaster base is being developed.

OP 85-83. Comparison of Magnetic Properties of Natural Mischmetal and Synthetic Mischmetal Alloyed With Cobalt, Copper, and Magnesium, by J. W. Walkiewicz, E. Morrice, and M. M. Wong. Pres. at 21st Intermag Conf., Philadelphia, PA, Apr. 5-8, 1983; pub. in *IEEE Trans. on Magnetics*, v. MAG-19, No. 5, September 1983, pp. 2053-2055. One of the objectives of the Bureau of Mines is to develop substitutes for scarce materials. Alloys containing mischmetal, lanthanum, praseodymium, neodymium, cobalt, copper, and magnesium were evaluated for use in permanent magnets in lieu of Sm-Co alloys. Magnets were fabricated by powder metallurgy techniques that consisted of arc melting the metals, crushing and grinding the resultant alloy, aligning and compacting the powder, and sintering the green compacts. A cerium-free synthetic mischmetal consisting of La-Pr-Nd was developed that had substantially better magnetic properties than natural mischmetal when alloyed with cobalt, copper, and magnesium.

OP 86-83. Synthetic Construction Aggregate Developed From Phosphate Fertilizer Waste, by Alexan-

der May, John W. Sweeney, and James R. Cobble. Pres. at SME-AIME Fall Meeting and Exhibit, Salt Lake City, UT, Oct. 19-21, 1983, SME preprint 83-300, 15 pp. In its role of providing technology to promote the efficient use of minerals and mineral process waste, the U.S. Bureau of Mines conducted research at its Tuscaloosa (AL) Research Center to identify and develop high-volume uses for phosphogypsum. Mixtures containing a maximum of 5 pct phosphogypsum, 6 to 10 pct lime, and the remainder fly ash had compressive strengths as high as 4,800 psi. The effects of the amounts of phosphogypsum, lime, and fly ash were investigated. Also, the effects of fly ash to lime ratios were studied.

OP 87-83. Compact Unit Collects Mine and Mill Dust, by Jon Sandstedt and Steven Page. *Min. Equip. Int.*, v. 7, No. 10, pp. 41-44. Wet collectors and water spray systems usually provide adequate dust control for underground and surface applications at low cost. However, there are applications where water usage cannot be tolerated because of availability, disposal, or material handling problems. In trona mines, for example, water mixes with trona dust to form a cement-like material that is difficult to remove. This report describes a dry dust collector, developed under a Bureau of Mines contract, that has the dry fabric filtration advantages of (1) high efficiency, (2) easy material handling, and (3) all temperature operation, while minimizing the usual disadvantages of frequent maintenance and large size.

OP 88-83. Effect of Microorganisms on In Situ Uranium Mining, by Marylynn V. Yates, James A. Brierley, Corale L. Brierley, and Steven Follin. *Appl. Environ. Microbiol.*, v. 46, No. 4, October 1983, pp. 779-784. The extraction of some metal values, e.g., uranium or copper, may be accomplished by using solutions to remove metals from ore bodies without practicing conventional mining. This process is referred to as in situ leaching and has been used industrially to recover uranium. The growth of microbial populations during in situ leaching is believed to be one of the causes of flow path plugging in the ore body, which results in decreased uranium production. Leach solution and solid samples from well casings and submersible pumps were collected from an in situ mining operation experiencing plugging problems. *Bacillus* sp., *Micrococcus* sp., pseudomonads, and xanthomonads were isolated from these samples on concentrations of 10⁶ colony-forming units per milliliter. A mixed culture of these organisms was inoculated into a uranium core specimen in the laboratory to assess the role of microbes in the plugging problem. A one-third decrease in permeability was effected in 16 days. Hydrogen peroxide killed the microorganisms in the core and alleviated the plugging problems. Periodically injecting hydrogen peroxide into the ore body through the production wells may reduce microbial plugging problems.

INDEX OF BUREAU OF MINES PUBLICATIONS

ABBREVIATIONS

CT	Computer Tape	MP	Mineral Perspective
FBG*	Florida Bureau of Geology	MY†	Minerals Yearbook
GS*	Geological Survey	OFR	Open File Report
HB	Handbook	OP	Outside Publication
IC	Information Circular	P	Patent
MCP	Mineral Commodity Profile	RI	Report of Investigations
MI	Mineral Issue	SP	Special Publication
MLA	Mineral Land Assessment	TPR	Technical Progress Report

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