Bureau of Mines
Special Publication

LIST OF BUREAU OF MINES PUBLICATIONS AND ARTICLES

January 1 to December 31, 1981

With Subject and Author Index

Compiled by Staff, Branch of Editorial Services

UNITED STATES DEPARTMENT OF THE INTERIOR

1982

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UNITED STATES DEPARTMENT OF THE INTERIOR

James G. Watt, Secretary

BUREAU OF MINES

Robert C. Horton, Director

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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CONTENTS

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January 1 to December 31, 1981

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 describes reports and articles published during the period January 1 to December 31, 1981. It 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] and 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 list of publications and articles from January 1 to December 31, 1980.[7]

[1] Available from National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, Va. 22161, PB 295 062/AS.

[2] Available from NTIS, PB 295 432/AS.

[3] Available from NTIS, PB 295 481/AS.

[4] Available from NTIS, PB 198 112/AS.

[5] Available from NTIS, PB 252 843/AS.

[6] Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. GPO Stock No. 024–004–02079–2. $12.

[7] Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. GPO Stock No. 024–004–02096–2. $6.

BUREAU PUBLICATIONS

Some Bureau of Mines publications, including 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, D.C. 20402, to whom orders should be sent directly. Payment for such publications should be made by check or money order payable to the Superintendent of Documents and should accompany the order. Publications cannot be mailed before payment is received. Payment for orders going to foreign countries should be made by International Postal Money Order, by draft on a U.S. or Canadian bank, or by UNESCO Coupons. Orders received with postage stamps, International Response Coupons, or foreign money will be returned. No charge is made for postage on publications mailed to points within the United States or its possessions. There is a special handling charge on all 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, 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 one 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. They rarely represent the first public report on the subject. As a rule, Bulletins encompass published work together with essential unpublished data and details.

Minerals Yearbook—annual statistical publication of the Bureau—summarizes 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.

Reports of Investigations present the results of research and investigations conducted by the Bureau at its research centers or laboratories, or in mines, quarries, smelters, refineries, oilfields, plants, and other non-Bureau properties. 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. Reports of Investigations may include a summary of several projects or activities in a given subject area that are not necessarily related directly to each other, new technical or economic theory, mineral resource studies that emphasize original evaluation of deposits, results of laboratory analyses of an unusual nature, and comparative and nonroutine testing of cores, explosives, and other commodities.

Information Circulars differ from Reports of Investigations in that they are not concerned primarily with original Bureau research or investigative work. They 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).

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. They are expanded fact sheets 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.

Mineral Commodity Profiles are designed to supplement the Minerals Yearbook and Mineral Facts and Problems. Comprehensive data will be presented for each commodity, including background information on industry structure, technology, resources and reserves, timely economic and production data, and forecasts of future supply-demand relationships and uses. Data in the Mineral Commodity Profiles will be the latest available at the time of issue.

Mineral Issues series comprises reports that identify and evaluate mineral policy issues to assist Government and private sector analysts and decisionmakers. They 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.

Mineral Perspectives present the latest available data on commodities that are of critical importance in a particular foreign country or region of the world.

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 personnel, Handbooks cover a wide range of subjects.

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, and 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 States, and final figures are published in Volume II of the Yearbook.

Special Mineral Commodity Publications are issued to help domestic producers and consumers of mineral commodities keep abreast of developments in the mineral industries and markets, both domestic and foreign, and provide a brief summary of significant information from U.S. Foreign Service offices and other sources, which may otherwise not be made available to the general public.

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.

Computer tapes and printouts are occasionally available containing mineral data.

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 in a library or Bureau facility. See the list of open file reports for information as to where they are available for examination. Some open file reports can be purchased from the National Technical Information Service of the U.S. Department of Commerce in paper copy or microfiche.

Mineral Land Assessments, a special open file report series, present 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 (OP's) 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 from January 1 to December 31, 1981, 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 by the National Technical Information Service, U.S. Department of Commerce, are listed in the section "Reports Available From the National Technical Information Service."

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. 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. The following Mineral Industry Surveys were being published in 1981 by the Bureau of Mines.

MONTHLY

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

QUARTERLY

Antimony.
Bauxite.
Bismuth.
Cadmium.
Copper Sulfate.
Fluorspar.
Magnesium.
Mercury.
Platinum-Group Metals.
Selenium.
Titanium.

ANNUALLY

Abrasive Materials.
Aluminum.
Antimony.
Asbestos.
Barite.
Beryllium.
Bismuth.
Boron.
Bromine.
Cadmium.
Calcium-Magnesium Chloride.
Cement.
Cesium and Rubidium.
Chromium.
Clays.
Cobalt.
Columbium and Tantalum.
Copper Industry.
Diatomite.
Feldspar and Related Minerals.
Ferroalloys.
Fluorspar.
Gallium.
Gem Stones.
Gold and Silver.
Graphite, Natural.
Gypsum.
Iodine.
Iron and Steel.
Iron and Steel Scrap.
Iron Ore.
Iron Oxide Pigments.
Lead Industry.
Lime.
Lithium.
Magnesium and Magnesium Compounds.
Manganese.
Mercury.
Mica.
Minor Nonmetals.
Molybdenum.
Nickel.
Nitrogen.
Peat.
Peat Producers.

Perlite.
Phosphate Rock.
Phosphate Rock (Crop Year).
Platinum-Group Metals.
Potash.
Potash (Crop Year).
Pumice and Volcanic Cinder.
Quartz Crystal.
Rare-Earth Elements and Thorium.
Rhenium.
Salt.
Sand and Gravel.
Selenium and Tellurium.
Silicon.
Slag, Iron and Steel.
Sodium Compounds.
Stone.
Sulfur.
Talc, Soapstone, and Pyrophyllite.
Tin.
Titanium.
Tungsten.
Vanadium.
Vermiculite.
Zinc Industry.
Zirconium and Hafnium.

SPECIAL MINERAL COMMODITY PUBLICATIONS

The following publications are issued to assist producers or consumers of mineral commodities to keep abreast of developments in the mineral industries. The publications provide brief summaries or tabulations of significant information from various sources. These publications may be obtained from the Section of Publications, Bureau of Mines, 4800 Forbes Avenue, Pittsburgh, Pa. 15213.

Minerals & Materials—A Monthly Survey. This monthly publication provides information on 12 strategic minerals in terms of major economic variables—consumption, production, imports, exports, inventories, and prices. The "Highlights" section focuses on major news events in nonfuel mineral commodities. Frequently, feature articles appear analyzing some aspect of the mineral industry.

Mineral Commodity Summaries. Issued annually, this publication gives preliminary data, in summary form, for most metals and nonfuel minerals.

1980 MINERALS YEARBOOK

The 1980 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, D.C. 20402

Volume I, Metals and Minerals, prepared by the staff of the Bureau of Mines. 1981. 72 ch. 950 pp. GPO Stock No. 024-004-02087-3. $17. Volume I of the Minerals Yearbook contains chapters on metal and nonmetal commodities. Volume I contains a general review chapter on mining and quarrying trends.

Volume II, Area Reports: Domestic, prepared by the staff of the Bureau of Mines. 1982. 52 ch. 603 pp. GPO Stock No. 024-004-02095-4. $14. Volume II 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. Volume II has a statistical summary on crude nonfuel mineral production.

Volume III, Area Reports: International, prepared by the staff of the Bureau of Mines. 1982. 92 ch. 1367 pp. GPO Stock No. 024-004-02093-8. $20. Volume III 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.

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, Division of Mineral Land Assessment, Washington, D.C., and at the National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Specific reports are also available at the field office indicated at the end of each entry.

MLA 1–81. Summary of Mineral Resources of the Lake Fork RARE II Area (Study Area 6290) Baker and Wallowa Counties, Oregon, by Martin D. Conyac. 1981. 9 pp. 1 fig. Western Field Operations Center, Spokane, Wash.

MLA 2–81. Mineral Resources of the John Muir Wilderness; Fresno, Inyo, Madera, and Mono Counties, California, by Frederick L. Johnson, Horace K. Thurber, Richard W. Morris, Thomas J. Peters, and D. S. Lindsey. 1981. 18 pp. 1 fig. Western Field Operations Center, Spokane, Wash.

MLA 3–81. Mineral Resources of the Big Butte-Shinbone (5145), East Fork (5226), Murphy Glade (5298), and Wilderness Contiguous (5137) RARE II Proposed Additions to the Yolla Bolly-Middle Eel Wilderness, Trinity, Tehama, and Mendocino Counties, California, by Warren D. Longwill. 1981. 13 pp. 1 fig. Western Field Operations Center, Spokane, Wash.

MLA 4–81. Summary Report on Mineral Resources of the West Pioneer RARE II Area, No. 1–006, Beaverhead County, Montana, by John R. Benham. 1981. 12 pp. 1 fig. Western Field Operations Center, Spokane, Wash.

MLA 5–81. Mineral Resources and Potential of Goat Rocks RARE II Areas, No. 6036, Parts A, C, and D, Lewis and Yakima Counties, Washington, by Thomas J. Peters and J. Mitchell Linne. 1981. 9 pp. 1 fig. Western Field Operations Center, Spokane, Wash.

MLA 6–81. Mineral Resources of the Hyalite-Porcupine-Buffalo Horn Wilderness Study Area (RARE II Areas No. 1–158 G, Gallatin Divide; and H. Hyalite), Gallatin and Park Counties, Montana, by Terry J. Close, J. Douglas Causey, Spencee L. Willett, and Clayton M. Rumsey. 1981. 11 pp. 1 fig. Western Field Operations Center, Spokane, Wash.

MLA 7–81. Mineral Resources of the Tepusquet Peak RARE II Area (No. 5–116), Santa Maria County, California, by Dale William Avery. 1981. 6 pp. 1 fig. Western Field Operations Center, Spokane, Wash.

MLA 8–81. Mineral Resources of the Carson-Iceberg Area (RARE II C-4–986, C-5–986, B-5–986 North, and B-5–986 South), Alpine and Tuolumne Counties, California, by Michael Miller. 1981. 16 pp. 1 fig. Western Field Operations Center, Spokane, Wash.

MLA 9–81. Mineral Resources of the Cuyama RARE II Study Area 5–135, Santa Barbara and Ventura Counties, California, by Lucia Kuizon. 1981. 11 pp. 1 fig. Western Field Operations Center, Spokane, Wash.

MLA 10–81. Mineral Resources of the Domeland Addition (5207) and Woodpecker (5206) RARE II Areas, Tulare and Kern Counties, California, by James M. Spear and Robin McCulloch. 1981. 11 pp. 1 fig. Western Field Operations Center, Spokane, Wash.

MLA 11–81. Mineral Resources of the Windigo Theilson RARE II Area, No. 6132, Douglas and Klamath Counties, Oregon, by John R. Benham. 1981. 6 pp. 1 fig. Western Field Operations Center, Spokane, Wash.

MLA 12–81. Mineral Resources of the Caney Creek Wilderness Area, Polk County, Arkansas, by Maynard L. Dunn, Jr., and Donald K. Harrison. 1981. 33 pp. 10 figs. Eastern Field Operations Center, Pittsburgh, Pa.

MLA 13–81. Mineral Resources of the Shining Rock Wilderness; Haywood County, North Carolina, by Maynard L. Dunn, Jr. 1981. 17 pp. 3 figs. Eastern Field Operations Center, Pittsburgh, Pa.

MLA 14–81. Mineral Resources of the Granite Chief RARE II Area (A5–261), Placer County, California, by Francis E. Federspiel, Eric E. Cather, and Douglas F. Scott. 1981. 13 pp. 1 fig. Western Field Operations Center, Spokane, Wash.

MLA 15–81. Mineral Resources of the Gee Creek Wilderness Area, Polk and Monroe Counties, Tennessee, by Gertrude C. Gazdik and Paul T. Behum. 1981. 31 pp. 6 figs. Eastern Field Operations Center, Pittsburgh, Pa.

MLA 16–81. Mineral Resources of the Linville Gorge Wilderness and Additions, Burke and McDowell Counties, North Carolina, by Gertrude C. Gazdik and Donald K. Harrison. 1981. 34 pp. 6 figs. Eastern Field Operations Center, Pittsburgh, Pa.

MLA 17–81. Mineral Resources of the Lye Brook Wilderness, Bennington and Windham Counties, Vermont, by Donald K. Harrison. 1981. 21 pp. 4 figs. Eastern Field Operations Center, Pittsburgh, Pa.

MLA 18–81. Mineral Resources of the Bristol Cliffs Wilderness Areas, Addison County, Vermont, by Peter C. Mory. 1981. 15 pp. 5 figs. Eastern Field Operations Center, Pittsburgh, Pa.

MLA 19–81. Mineral Resources of the Sipsey Wilderness and RARE II Areas, Lawrence and Winston Counties, Alabama, by Peter C. Mory, Robert B. Ross, Jr., and Paul T. Behum. 1981. 42 pp. 9 figs. Eastern Field Operations Center, Pittsburgh, Pa.

MLA 20–81. Mineral Resource Potential of the Upper Priest Lake RARE II Area (A1–123), Bonner County, Idaho, by David K. Denton, Jr. 1981. 9 pp. 1 fig. Western Field Operations Center, Spokane, Wash.

MLA 21–81. Mineral Resources of the Blue Joint Mtn. RARE II Area (No. 1–941), Ravalli County, Montana, by John R. Benham. 1981. 8 pp. 1 fig. Western Field Operations Center, Spokane, Wash.

MLA 22–81. Mineral Resources of the Buttermilk RARE II Area (No. 5–038), Inyo County, California,

by Stephen R. Iverson. 1981. 7 pp. 1 fig. Western Field Operations Center, Spokane, Wash.

MLA 23–81. Mineral Resources of the Little Frog Mountain RARE II Area, Polk County, Tennessee, by Gertrude C. Gazdik. 1981. 15 pp. 2 figs. Eastern Field Operations Center, Pittsburgh, Pa.

MLA 24–81. Mineral Resources of the Dinkey Lakes RARE II Area (No. 5244), Fresno County, California, by Francis E. Federspiel, Harry W. Campbell, Douglas F. Scott, and James M. Spear. 1981. 14 pp. 1 fig. Western Field Operations Center, Spokane, Wash.

MLA 25–81. Mineral Resources of the Fisher Gulch RARE II Area (No. A5299), Trinity County, California, by Eric E. Cather and Joseph L. Ritchey. 1981. 10 pp. 1 fig. Western Field Operations Center, Spokane, Wash.

MLA 26–81. Mineral Resources of the Black Butte RARE II Area (No. 5102), Monterey County, California, by Scott A. Stebbins. 1981. 9 pp. 1 fig. Western Field Operations Center, Spokane, Wash.

MLA 27–81. Mineral Resources of Belle Starr East RARE II Further Planning Area and Belle Starr West RARE II Further Planning Area; Scott and Sebastian Counties, Arkansas, by Lyle E. Harris. 1981. 25 pp. 6 figs. Eastern Field Operations Center, Pittsburgh, Pa.

MLA 28–81. Mineral Resources of the James River Face Wilderness; Rockbridge and Bedford Counties, Virginia, by Robert B. Ross, Jr., and Gertrude C. Gazdik. 1981. 16 pp. 3 figs. Eastern Field Operations Center, Pittsburgh, Pa.

MLA 29–81. Mineral Resources of Ellicott Rock Wilderness Area and Additions; Oconee County, South Carolina, Macon and Jackson Counties, North Carolina, and Rabun County, Georgia, by Gertrude C. Gazdik. 1981. 45 pp. 4 figs. Eastern Field Operations Center, Pittsburgh, Pa.

MLA 30–81. Mineral Resources of the Natural RARE II Further Planning Area; Baker County, Florida, by Thomas M. Crandall. 1981. 22 pp. 3 figs. Eastern Field Operations Center, Pittsburgh, Pa.

MLA 31–81. Mineral Resource Potential of the Arnold Mesa RARE II Further Planning Area, Yavapai County, Arizona, by Robert A. McColly and Stanley L. Korzeb. 1981. 11 pp. 2 figs. Intermountain Field Operations Center, Denver, Colo.

MLA 32–81. Mineral Resource Investigation Burden Falls RARE II Further Planning Area; Pope County, Illinois, by Robert M. Thompson. 1981. 13 pp. 3 figs. Eastern Field Operations Center, Pittsburgh, Pa.

MLA 33–81. Mineral Resources of Troublesome Further Planning Area; McCreary County, Kentucky, by Robert B. Ross, Jr., and Richard W. Hammack. 1981. 21 pp. 5 figs. Eastern Field Operations Center, Pittsburgh, Pa.

MLA 34–81. Mineral Resources of the La Panza RARE II Area (No. 5109), San Luis Obispo County, California, by Donald J. Barnes. 1981. 10 pp. 1 fig. Western Field Operations Center, Spokane, Wash.

MINERAL ISSUES

The following publications are the first in a new Bureau of Mines series addressing contemporary mineral policy issues. Reports in the series will 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.

The following reports are sales publications and can only be ordered from—

Superintendent of Documents
Government Printing Office
Washington, D.C. 20402

MI. The Nonfuel Mineral Outlook for the U.S.S.R. Through 1990, by James S. Grichar, Richard Levine, and Lotfollah Nahai. 1981. 17 pp. The U.S.S.R. is one of the largest producers, consumers, and exporters of nonfuel minerals in the world. In addition, it has one of the world's largest resource bases. Recently, some analysts have concluded that the U.S.S.R. will become import dependent for a broad range of nonfuel minerals. To examine this question in greater detail, the Bureau of Mines held a symposium on this topic and had papers prepared on the subject. This study not only draws on those papers but sets forth an outlook for the Soviet Union's nonfuel mineral position through 1990. GPO Stock No. 024–004–02090–3. $2.25.

MI. The U.S. Copper Industry: Problems, Issues, and Outlook, by Louis J. Sousa. 1981. 86 pp. 9 figs. The domestic copper industry has been through a difficult period over much of the past decade. The numerous problems facing the copper industry have resulted in generally poor profitability, little improvement in productivity, and a trend of increasing imports. In this Bureau of Mines report, the principal problems facing the copper industry are identified and their impact on the industry's performance and outlook are assessed. The study revealed that the relatively low grade of U.S. copper ores and the high cost of labor compared with grades and costs in several developing countries are major problems hindering the domestic copper industry, that several smelters in this country are in need of renovation in order to better compete with foreign copper producers, and that several Government policies have had a negative effect on the copper industry. In spite of these problems, the magnitude of the U.S. copper reserve seems to assure that the country will remain a major producer. While the potential long-run outlook for copper mining in the United States is generally favorable, a major unknown is the future status of smelting in this country. GPO Stock No. 024–004–02083–1. $5.

REPORTS OF INVESTIGATIONS

The following publications can be obtained from—

Section of Publications
Bureau of Mines
U.S. Department of the Interior
4800 Forbes Avenue
Pittsburgh, Pa. 15213

RI 8500. Preparation of Platinum-Palladium Flotation Concentrate From Stillwater Complex Ore, by J. Bennetts, E. Morrice, and M. M. Wong. 1981. 18 pp. 9 figs. As part of its mission to develop technology that will help increase the supply of critical and strategic minerals from domestic resources, the Bureau of Mines has investigated methods for beneficiating platinum-group metal ores from the Stillwater complex, Montana. This report presents the result of a bench-scale study employing froth flotation to recover a sulfide concentrate containing platinum-palladium values from a mineralized gabbro. Best results were obtained with a flotation scheme utilizing a mercaptobenzothiazone collector and sulfuric acid. Rougher concentrates containing approximately 11 oz Pt-Pd/ton and 90 pct of the metal values in the ore were obtained. Subsequently, cleaner concentrates containing approximately 26 oz Pt-Pd/ton and between 80 to 85 pct of the Pt-Pd values in the ore were prepared.

RI 8502. Amine Flotation of Chromite Ores From the Stillwater Complex, Mont., by G. E. Smith, J. L. Huiatt, and M. B. Shirts. 1981. 12 pp. 2 figs. The Bureau of Mines, U.S. Department of the Interior, devised a flotation technique for upgrading chromite in chromium ores and gravity concentrates. The technique consisted of cationic flotation of chromite from a slime-free pulp acidified to pH 2.5 or lower using H_2SO_4 modifier. Flotation results showed that ore containing serpentine as the primary gangue mineral was more amenable to concentration by this technique than ore containing the readily floatable olivine as the primary gangue mineral. Rougher flotation of a chromite ore containing abundant serpertine increased the grade form 19 to 41 percent Cr_2O_3 at a chromite recovery of 89.6 percent. Rougher flotation of ore containing abundant olivine upgraded the chromite from 23.4 to 29.6 percent Cr_2O_3 at a recovery of 89.4 percent. The technque was also applied to chromite gravity concentrates to further upgrade chromite and to reject silicates. Flotation of a gravity concentrate containing 40.9 percent Cr_2O_3 and 4.4 percent SiO_2 recovered 90 percent of the chromite in cleaner products containing 44.9 percent Cr_2O_3 and 0.63 percent SiO_2. The combined recovery by gravity and flotation was 87 percent. An economic evaluation of this technique will be undertaken to determine its feasibility for commercial use.

RI 8503. Autogenous Attrition Microgrinding of Calcium Carbonate Minerals, by J. P. Hansen, E. G. Davis, and G. V. Sullivan. 1981. 15 pp. 8 figs. To help assure an adequate domestic supply of minerals essential to the Nation's economy and security by developing more efficient minerals extraction technologies, the Bureau of Mines' Tuscaloosa Research Center examined the application of autogenous microgrinding to calcium carbonate minerals. Treatment of minus 8-mesh Alabama marble resulted in a product 80 pct minus 5 micrometers (μm) at a power consumption of 70 to 80 kwhr/ton. This study shows that coarse particles of calcium carbonate minerals are effective as the grinding media for the autogenous attrition grinding of these minerals. The minus 8- plus 30-mesh fraction is an effective grinding medium (sand) for particles smaller than 30 mesh. A 40-pct-solids slurry and a sand-marble ratio of 2.5 appeared to be near optimum. For residence times above 13 minutes, products were greater than 80 pct minus 5 μm and greater than 54 pct minus 2 μm. Power consumption was uniformly low, ranging from 50 to 100 kwhr/ton of product depending upon the feed rate. One marble sample from Georgia was shown to be the most persistent grinding medium, with losses of less than half those of the other materials tested.

RI 8504. Corrosion of Materials and Scaling in Low-Salinity East Mesa Geothermal Brines, by F. X. McCawley, S. D. Cramer, W. D. Riley, J. P. Carter, and P. B. Needham, Jr. 1981. 17 pp. 10 figs. The Bureau of Mines, in pursuing its goal of extending the life span of strategic materials, conducted field corrosion studies at the East Mesa Known Geothermal Resources Area (KGRA) in the Imperial Valley, Calif., to determine the optimum materials of construction for use in geothermal mineral energy resource recovery plants. These studies included characterization of geothermal environments and in situ corrosion testing. The corrosion resistance of 10 alloys exposed to 5 brine and steam process environments was evaluated using the low-salinity, high-temperature brine from geothermal well Mesa 6–1. Of these alloys, Hastelloy C-276, Hastelloy S, Inconel 625, titanium-2nickel, and 316 L stainless steel had excellent resistance to corrosion in all of the process environments; E-Brite 26–1 and 430 stainless steel had fair resistance. Although general corrosion rates for 4130 steel and 1020 carbon steel were substantially higher than those of the other iron-base alloys, these two alloys could prove useful in low-salinity process environments because of their low cost. Aluminum alloy 5005 was the least corrosion resistant alloy and pitted severely. Scales formed on all of the alloys in every process environment. Calcite, aragonite, and an amorphous silicate were the major components of the scales.

RI 8505. Cationic Flotation of a Hematitic Oxidized Taconite, by H. D. Jacobs and A. F. Colombo. 1981. 11 pp. 3 figs. The Federal Bureau of Mines, as part of a program to insure future raw material needs for the iron and steel industry, undertook research to beneficiate the oxidized taconites from the western Mesabi range in Minnesota. The data presented were obtained by applying the Bureau-developed selective-flocculation / cationic-flotation process to the second of three oxidized taconite samples. These three samples are representative of an estimated 10 billion tons of ore analyzing 30 to 40 pct iron. The experimental work was performed in a 900-lb/hr pilot plant. Treating the ore sample (36.1 pct Fe) with the Bureau's process produced commercially acceptable concentrates averaging 63.5 Fe and 4.3 pct SiO_2, with an average iron recovery of 84.6 pct.

RI 8508. Airblast Instrumentation and Measurement Techniques for Surface Mine Blasting, by Virgil J. Stachura, David E. Siskind, and Alvin J. Engler.

1981. 53 pp. 40 figs. The Bureau of Mines has investigated techniques and instrumentation that measure accurately the airblast overpressures from surface mine blasting. The results include equivalencies between broadband research instrumentation and commercially available impulse precision sound level meters measuring: root-mean-square, peak, fast, slow, impulse, A and C weighting, C-weighted sound exposure level (CSEL), and "linear" (flat) response. These values were obtained from field measurements and broadband FM tape recordings of production blasts at area and contour coal mines, limestone quarries, and iron mines. Frequency response was determined for 14 commercial systems.

RI 8509. Flotation Responses of Two Duluth Complex Copper-Nickel Ores, by R. B. Schluter and W. M. Mahan. 1981. 24 pp. 12 figs. The Bureau of Mines investigated the flotation responses of two copper-nickel ore samples from the Duluth Complex with the objective of recovering bulk sulfide concentrates. One of the ores studied was taken from a test pit; the other was taken from a test shaft. The samples were quite similar except that the pit sample analyzed 0.35 pct Cu and 0.11 pct Ni and the shaft sample analyzed 0.69 pct Cu and 0.14 pct Ni. Flotation responses were studied in both laboratory and pilot plant tests. Pilot plant flotation responses were similar for both samples resulting in grades of 12.2 pct Cu and 2.5 pct Ni for the pit sample and 12.2 pct Cu and 2.1 pct Ni for the shaft sample. Weight recoveries were 2.5 pct for the pit sample and 5.2 pct for the shaft sample. Copper and nickel recoveries for the pit sample were 87 and 62 pct, respectively, and 92 and 73 pct for the shaft sample. Both concentrates contained small but significant values of cobalt and precious metals. Cobalt recoveries were low—less than 40 pct for both concentrates. Precious metals contents of the concentrates were 1.59 oz/ton for the pit sample and 0.99 oz/ton for the shaft sample. Silver was the predominant precious metal by weight, but platinum and palladium represented the highest values.

RI 8510. Determination of Antimony in Smelter Flue Dusts by Atomic Absorption Spectrometry, by K. R. Farley, K. W. Sheetz, and A. B. Whitehead. 1981. 9 pp. 1 fig. A simplified method for the atomic absorpton determination of antimony is described. Samples are dissolved in hydrobromic acid and diluted to volume with water. Solutions can be ready for analysis in about 10 minutes and are stable for at least 24 hours. The spectral line at 231 nanometers is used, and there is no effect on absorption resulting from the presence of any concentration of HBr. Absorbance is linear with antimony concentrations up to 120 micrograms per milliliter. Sensitivity is 1.48 micrograms per milliliter per 0.0044 absorbance. Relative errors on National Bureau of Standards Standard Reference Materials were 3 percent or less, and relative standard deviations on 12 determinations of each of three flue dust samples were 4 percent or less (95-percent confidence limit).

RI 8511. Electric-Arc Furnace Processing of Domestic Titaniferous Materials, by R. H. Nafziger, R. R. Jordan, and W. L. Hunter. 1981. 35 pp. 1 fig. The Bureau of Mines evaluated 18 domestic titaniferous materials with widely varying compositions, mineralogy, and physical properties in electric-arc furnaces. Techniques were devised to recover both the titanium and iron values contained in these materials so that the reliance of the United States on foreign sources of higher grade ilmenites and rutile might be decreased. Most of the tested titaniferous materials responded well to lower grade or byproduct reductants, such as bituminous coals, charcoal, and coke breeze. Sufficient slag fluidity was realized by maintaining from 8 to 12 wt-pct iron in the slags; no contaminating fluidizers were required. Fluid slags containing up to 79, 70, and 54 wt-pct TiO_2 were realized from east coast ilmenites, a rock ilmenite, and a titaniferous magnetite ore, respectively. A carbon-lined furnace shell is recommended for minimum slag contamination. Good results also were obtained during extended submerged-arc furnace tests.

RI 8512. Effectiveness of Wet Cutter Bars in Reducing Salt Mine Dust, by Steven J. Page, Charles W. Urban, and Jon C. Volkwein. 1981. 10 pp. 2 figs. Responding to the increasing concern for dust control in metal and nonmetal mining, the Bureau of Mines investigated typical dust reduction efficiencies of wet bar cutter machines as they are presently being used in salt mines. Wet bar techniques have previously been used in coal mines, achieving dust reduction efficiencies ranging from 11 to 60 pct. Two different wet bar techniques, namely, the front spray and the water trickle, have been studied as they are currently being used in two salt mines. Preliminary results show that the dust reduction efficiencies have a large variation (0 to 66 pct), as is the case for wet bars used in coal. However, whereas wet bars in coal required 3 to 4 gpm water consumption, wet bars in salt obtained similar efficiencies with only 0.1 to 0.4 gpm. The most reliable data obtained during this study show that the front spray system consistently performs at efficiencies between 41 and 66 pct, with an average of 54 pct. The results indicate that, although wet bar cutter techniques in salt mines are a relatively simple and inexpensive means of dust control with a minimum of water consumption, further investigation should be performed to fully evaluate and optimize wet bar cutter dust reduction efficiencies.

RI 8513. Effects of CO_2-Absorbent Canister Design on LiOH Efficiency in Closed-Circuit Breathing Apparatus, by Nicholas Kyriazi. 1981. 13 pp. 15 figs. It is of interest to know how to obtain as high an absorption efficiency as possible from a CO_2-absorption canister used in closed-circuit breathing apparatus. In this study the Bureau of Mines found that varying the bed depth and the cross-sectional area of a canister changes it absorption characteristics. In tests using four, rectangular, variable-depth canisters with different cross-sectional areas, the Bureau found that, given a constant weight of the chemical absorbent, LiOH, and a constant CO_2 input, the canisters with a greater cross-sectional area reached CO_2 levels of 0.5 volume-percent in the effluent gas sooner than did the canisters with a greater bed depth. However, resistance to flow through the canister increases with bed depth, and a trade-off is inevitable. It was anticipated that the efficiency of a canister would increase with increasing intergranular air space approaching the tidal volume of the breathing waveform and then level off at some point under 100 percent. This postulation was partiallv substantiated. Cylindrical and radial canisters were also tested and compared. It appears that shape is not as important a factor in absorption efficiency as bed depth, since neither canister differed significantly from the rectangular canisters with regard to absorption efficiency values.

RI 8514. Method for Preparing Ferrochromium Alloys by Vacuum Reduction and Simple Melting of Reduced Products, by J. E. Pahlman, M. L. Boucher, S. L. Payne, and S. E. Khalafalla. 1981. 22 pp. 11 figs. As part of its effort to reduce the need for strategic minerals through conservation and to reduce the capital and energy requirements of mineral processing, the Bureau of Mines has investigated a method for preparing ferrochromium alloys containing less than 2 percent carbon. This method will conserve chromium and should reduce the capital and energy requirements for chromite reduction. Reduced products containing less than 2 wt-pct C and as low as 0.01 wt-pct C were obtained by reacting pellets of chromite and carbonaceous reductant mixtures at pressures of 0.1 to 1 torr and temperatures of 1,230° to 1,320° C. The extent of reduction increased with increased temperature and decreased pressure; however, operating conditions were limited due to the onset of significant chromium vaporization at higher temperatures and lower pressures. Foundry coke, anthracite, and carbon black were found to be superior to graphite as reductants. The reduction of chromite to metallics was found to proceed via the carbide intermediates $(Fe,Cr)_7C_3$ and $(Fe,Cr)_{23}C_6$. No evidence of carbide intermediates Fe_3C or Cr_3C_2 was found. Buttons of ferrochrome alloys were made by melting a mixture of reduced products with CaO and SiO_2 at 1,700° C for 20 minutes in an induction furnace.

RI 8515. Direct Method Determination of the Gas Content of Coal: Procedures and Results, by W. P. Diamond and J. R. Levine. 1981. 36 pp. 9 figs. The explosion hazard of methane-air mixtures has become an increasingly serious mine planning problem, and an advance assessment of methane gas potential can therefore be essential for a safe and economic mine development program. As part of its coal mine health and safety program, the Bureau of Mines has developed a simple, inexpensive test to measure the methane content of coal samples obtained from exploration cores. The gas content of coal per unit weight as determined by the direct method test can be used as a basis for a preliminary estimate of mine ventilation requirements, and to determine if degasification of the coalbed in advance of mining should be considered. Since the Bureau began measuring the gas content of coal samples in 1972, experience has led to equipment and procedural changes, the most significant of which has been the development of a ball mill for crushing the coal sample to release the residual gas at the end of the desorption test period. This revised procedure replaces the crushing box and graphical methods described in earlier Bureau publications. The results of 583 direct method tests are summarized in tabular form. These results include data on the gas content of 125 coalbeds in 15 States.

RI 8516. Development of a Continuous Flotation Process for Removal of Insoluble Slimes From Potash Ore, by Philip Thompson and J. L. Huiatt. 1981. 21 pp. 7 figs. The Bureau of Mines investigated a selective flocculation-flotation technique to remove insoluble slimes from low-grade potash ore in a continuous 45-kilogram-per-hour (100-pound-per-hour) process investigation unit (PIU). This research is part of the Bureau's program to improve resource recovery from low-grade ores. Results showed that 84 percent of the insoluble slimes were removed from an ore containing 5.5 percent water-insolubles and 14 percent K_2O using a Bureau-developed, cationic flocculant-glycol ester-diesel oil reagent. Subsequent potash flotation recovered 75 percent of the potash in a cleaner concentrate assaying 56 percent K_2O. Concentrate leaching upgraded the product to market specifications of 60 percent K_2O. An economic evaluation by the Bureau suggested that the rate of return on investment, after taxes, should be about 20 percent for such an enterprise.

RI 8517. Thermal Degradation Products of Solvents and Hydraulic Fluids Used in Mining, by Theodore Christos and David R. Forshey. 1981. 14 pp. The Bureau of Mines sponsored an investigation of the thermal oxidative degradation characteristics of certain solvents and hydraulic fluids used in underground mining operations. The following halogenated solvents were studied in view of their usefulness and their flame retardant property: tetrachloroethylene, $Cl_2C = CCl_2$; 1, 1, 2-trichloroethane, ClH_2CCHCl_2; and trichloroethylene, $Cl_2C = CHCl$. The hydraulic fluids studied were representative of five groups approved by the Mine Safety and Health Administration for underground operation, namely: glycol-water solutions, mineral oil-water emulsions, synthetics other than phosphate esters, synthetic phosphate esters, and mixures of phosphate esters with mineral oils and other ingredients. It was observed that the partially halogenated solvents present a greater potential toxic hazard than the fully halogenated materials, due not only to the easy production of hydrogen chloride but also to their ease of oxidation leading to the formation of phosgene and carbon monoxide. The pure phosphate esters exhibited the best thermal oxidative stability of the five groups of hydraulic fluids tested. A fluid containing phosphate esters mixed with mineral oils and other unidentified ingredients appeared to be the most hazardous on the basis that it produced very toxic acrolein and phosphine.

RI 8518. Selective Extraction of Metals From Pacific Sea Nodules With Dissolved Sulfur Dioxide, by S. E. Khalafalla and J. E. Pahlman. 1981. 26 pp. 7 figs. In support of its goal to maintain an adequate supply of minerals to meet national economic and strategic needs, the Bureau of Mines has investigated a novel hydrometallurgical system with sulfur dioxide. Differential leaching with dissolved SO_2 of manganese, nickel, and cobalt from their hydrous oxides was found to be very rapid and efficient—almost instantaneous and quantitative. In this method a given weight of mixed oxides previously ground to minus 200-mesh is slurried with a leach solution containing a specified quantity of dissolved SO_2 for 10 minutes at room temperature and ambient pressure. An empirical leaching parameter, R, is defined as the ratio of the number of SO_2 moles in the leaching solution to the weight of the metal oxide charge. Plots of the variation of metal extraction with the ratio R generate a series of sigmoidal-shaped curves, each of which is characteristic of a specific metal extraction. A threshold value of R is required to initiate the leaching of a given metal from the mixed oxides. Once this threshold is reached, the metal recovery can increase to more than 95 pct in very short times.

RI 8519. Effects of Humidity on Salt Mine Dust: A Preliminary Report, by J. C. Volkwein, R. P. Vinson, and E. D. Thimons. 1981. 9 pp. 3 figs. A preliminary study was conducted by the Bureau of Mines to determine the effect of humidity on salt mine airborne dust levels. Results showed less dust

where the humidity was elevated. Dust reductions appeared to be dependent on the equilibrium between humidity and salt.

RI 8520. Alternative Methods for Copper Recovery From Dump Leach Liquors, by B. W. Madsen and R. D. Groves. 1981. 17 pp. 7 figs. The Bureau of Mines conducted large-scale laboratory copper ore leaching tests to enable improving copper recovery from large dump-leaching operations. This was done by comparing leaching progress when copper was recovered from recycled leach liquor either by cementation or by solvent extraction. Copper was leached from 7-ton ore samples at room temperature using pH 2 ferric sulfate solutions. With ore samples containing 11 percent minus 0.5-inch fines, no marked advantage in using either of the copper recovery methods was evident after 416 days of leaching. With ore containing 32 percent minus 0.5-inch fines, solvent extraction of copper was advantageous in that 60 percent of the copper was extracted after 568 days, whereas only 48 percent of the copper was extracted when cementation was used. Less acid was consumed during leaching when solvent extraction, rather than cementation, was used for copper recovery. Iron, contributed by cementation with scrap iron, plugged the ore bed containing 32 percent fines.

RI 8521. Fire Resistance Test Method for Conveyor Belts, by M. J. Sapko, K. E. Mura, A. L. Furno, and J. M. Kuchta. 1981. 27 pp. 8 figs. A moderately scaled apparatus was developed by the Bureau of Mines to determine the fire resistance characteristics of mine conveyor belts and similar type materials. The design of the apparatus was based upon data obtained in full-scale fire tests and features a radiant panel to preheat the belt and a methane-oxygen ribbon burner to ignite the sample under ventilating conditions in a rectangular duct. The test method overcomes the limitations of existing laboratory-scale methods and provides a measure of both ignitability and flammability in quantitative terms. Flame propagation depended upon such variables as air velocity, ignitor heat flux, and belt width and height in the test chamber. Data are presented for nine belt materials and fire resistance ratings are proposed in terms of the flame spread rate, heat release rate, and the critical ignitor heat flux. The ratings discriminate between the fire hazard posed by different fire-resistant belts and tend to be in reasonable agreement with those obtained in full-scale fire tests.

RI 8522. Low-Pressure Leaching of Duluth Complex Matte, by L. A. Haas, R. B. Schluter, and R. H. Nafziger. 1981. 12 pp. 9 figs. The Bureau of Mines conducted bench-scale leaching tests with recycled spent copper electrolytes and copper-nickel mattes produced from the Minnesota Duluth Complex concentrates. This report describes the first stage of an overall two-stage leach operation. The objective of this research was to determine the matte-leach technology required to convert spent copper elecrolyte into an enriched nickel liquor suitable for a nickel refinery and therefore essentially free of copper, iron, and sulfuric acid. The experimental variables investigated were matte composition, particle size, spent electrolyte content, pulp concentration, oxygenation, temperature, and time. The time required to produce an enriched purified nickel liquor decreased with increasing pulp concentration, temperature, and oxygenation, but increased with increasing particle size and electrolyte copper and acid content. Nickel-rich (about 50 g/l) liquors at a pH of about 4 and containing less than 1 g/l of copper and iron were produced at 70° C by leaching minus 325-mesh low-iron (less than 5 pct) matte for 8 hours with spent electrolyte containing 22.4 g/l Cu, 28.9 g/l Ni, less than 0.1 g/l Fe, and 50 g/l H_2SO_4 at a pulp concentration of 1 kg of matte per liter of spent electrolyte. Varying the nickel content of the spent electrolyte from 11 to 101 g/l appeared to have no appreciable influence on the matte leaching characteristics.

RI 8523. Recovery of Lithium From Clay by Selective Chlorination, by C. F. Davidson. 1981. 19 pp. 12 figs. The Bureau of Mines studied the extraction of lithium from lithium-containing clays by chlorination with hydrogen chloride (HCl). In bench-scale laboratory investigations, $HCl-H_2O$ mixtures were used to selectively chlorinate lithium, but not calcium or magnesium, in lithium-containing clays. The addition of calcium carbonate to the clay was found to improve the lithium recovery. Reaction conditions found to affect the lithium recovery were ratio of clay to carbonate, reaction temperature, and HCl concentration. The best conditions for selective chlorination of the lithium were 2:1 clay-carbonate, 750° C, and 20 wt-pct HCl. The experimental results and trends in lithium extraction are explained using thermodynamic relationships.

RI 8524. Electrowinning Zinc From Zinc Chloride in Monopolar and Bipolar Fused-Salt Cells, by S. D. Hill, D. L. Pool, and G. A. Smyres. 1981. 24 pp. 16 figs. To help insure the continued viability of the minerals and materials sector of the U.S. economy, the Bureau of Mines is conducting research and disseminating technology that will result in more efficient minerals extraction. As part of this effort, a process is being investigated that involves an aqueous chlorine-oxygen leaching procedure to treat complex sulfide concentrates to produce $ZnCl_2$. Subsequent fused-salt electrolysis of the $ZnCl_2$ produces high-purity zinc metal. Previous reports described preliminary, small-scale research on the chlorine-oxygen leaching system and fused-salt electrolysis of $ZnCl_2$. This report discusses the details of design, construction, and long-term, continuous operation of both monopolar and biopolar fused-salt cells. The effects of temperature, electrode gap, current density, electrolyte composition, and electrode configuration on current efficiency and energy consumption were determined for a $ZnCl_2$-KCl-NaCl electrolyte system. Zinc metal was produced at the rate of about 50 lb/day in a monopolar cell which was operated continuously for 60 days with current efficiencies from 85.8 to 98.6 pct and an average power consumption of 2.1 kwhr/lb. Bipolar cells with several different electrode configurations were operated for 90 days. A current efficiency of about 70 pct and power consumption of about 1.7 kwhr/lb of zinc were achieved using a three-electrode-pair, bipolar assembly with a chlorine gas lift pump to circulate electrolyte.

RI 8525. Assessing the Methane Hazard of Gassy Coals in Storage Silos, by John C. LaScola, Joseph E. Matta, and Fred N. Kissell. 1981. 9 pp. 5 figs. The Bureau of Mines investigated coal storage silos to determine how gassy coal must be for methane accumulations in a silo to become hazardous and where such accumulations are likely to occur. Methane concentrations were measured in the open space above the stored coal pile, in the pile, and in the

reclaiming area. No methane layering was found in closed-top silos. Reclaiming areas were as gassy as the top part of the silos. Coal samples were collected from the conveyors entering the silos in order to assess the gassiness of the coal. No simple correlation was found between the gassiness of the coal stored and the measured methane concentrations. However, at mines where the average 24-hour gas emissions from the conveyor belt samples was 14 ft^3/ton or more, fans or open tops were used. It appears that a large fraction of the methane released during storage remains in the void space between the coal particles.

RI 8526. High-Temperature Enthalpy and X-Ray Powder Diffraction Data for Aluminum Sulfide (Al_2S_3), by M. J. Ferrante and R. A. McCune. 1981. 10 pp. 1 fig. High-temperature enthalpy and X-ray powder diffraction studies were conducted on aluminum sulfide (Al_2S_3) as part of the Bureau of Mines effort to provide new data for the advancement of mineral technology consistent with environmental preservation and energy conservation Relative enthalpies were measured with a copper-block calorimeter from 298.15 to 879 K. Tabulated values are listed for heat capacity, entropy, Gibbs energy functions, and relative enthalpies between 298.15 and 900 K. Enthalpies were also given in the form of an equation and combined with published data to calculate standard enthalpies of formation and Gibbs energies of formation for reactions of crystalline aluminum with crystalline, liquid, and gaseous diatomic sulfur. The hexagonal, rhombohedral, and cubic phases of Al_2S_3 were identified by X-ray powder diffraction studies, and the indexed powder diffraction patterns of these phases are given. The hexagonal phase was stable to about 852 K and was partially converted to the rhombohedral form at 879 K.

RI 8527. SF_6 Tracer Gas Tests of Bagging-Machine Hood Enclosures, by Robert P. Vinson, Jon C. Volkwein, and Edward D. Thimons. 1981. 10 pp. 10 figs. This Bureau of Mines report presents the results of tracer gas studies conducted at three facilities where bagger hoods had been installed several years ago to remove airborne silica dust from the vicinity of the bagging operator. The studies indicated that for optimum benefits makeup air must be evenly dispersed, the hood enclosures and duct systems must be as airtight as possible, the average intake air velocity of each hood should be at least 200 fpm, and the hoods and duct systems must be properly maintained.

RI 8528. Feed Grade Versus Extraction Correlations on Uranium Ores From New Mexico, by P. L. Placek, A. G. Lawrence, I. L. Nichols, and D.C. Seidel. 1981. 52 pp. 18 figs. Correlations were made on experimental data for four New Mexico ore series to determine relationships between ore grade and uranium extraction during leaching operations. Such relationships provide information needed to predict the long-range supply of minerals to meet national economic and strategic needs. Results show that other ore constituents and gangue materials in addition to uranium grade influence uranium extraction. In general, tailing grades decrease and uranium extraction increases as both H_2SO_4 and $NaClO_3$ concentrations increase. Terminal emf and terminal pH also were studied. Similar trends appeared for all ores; however, specific combinations of results also were observed for individual ores and ore series. Experimental results indicate that uranium extractions are higher for lower uranium feed grades than predicted by other estimates.

RI 8529. Dewatering Florida Phosphatic Clay Wastes With Moving Screens, by L. W. Brandt. 1981. 16 pp. 8 figs. The Bureau of Mines, as part of its mission to effect pollution abatement, conducted research to study various means of dewatering Florida phosphatic clay wastes and reclaiming mined lands. The work was done in cooperation with 10 Florida phosphate companies. During this work, a novel technique to effectively dewater phosphatic clay wastes was developed. The solids contained in the clay waste slurry are slowly compressed by moving wire mesh screens through the system. In a typical application, the screens were moved downward, compressing solids ahead of the screens. The rate of movement of the screens is an important variable in the process. It is believed that the moving screens distort the gel structure of the phosphatic clay system and cause the release of water. Samples of 18 clay wastes, including a high-grade attapulgite from beneficiation plants of the Florida phosphate field, were studied using the method. Typical samples were concentrated from initial solids of 4.7 and 11.9 percent to 16.8 and 25.2 percent, respectively, in 3-1/2 days. The high-grade attapulgite sample was dewatered from 2.7 percent solids to 13 percent solids in the same period.

RI 8530. An Evaluation of Used Aluminum Smelter Potlining as a Substitute for Fluorspar in Cupola Ironmelting, by V. R. Spironello and R. H. Nafziger. 1981. 14 pp. 3 figs. The Bureau of Mines is conducting studies of the slags related to ferrous technology to evaluate acceptable substitutes for the auxiliary flux, mineral fluorspar, in foundry operations. This work is directed toward the Bureau's goal of minimizing the Nation's dependence on scarce and critical minerals. Comparative basic practice cupola (18-inch-ID) trials were made to evaluate a waste material called "used potlining," which contains significant levels of fluorine, sodium, and aluminum in various compounds. Used potlining is recovered from alumina reduction cells after its useful life, and was supplied by the Aluminum Co. of America (Alcoa) to the Bureau for evaluation. The material in the lump and pelletized form (with limestone) provided extremely fluid slags based on visual observation during cupola operation. No adverse effects were found on cupola performance, metal and slag chemistry, the environment, or mechanical properties of the castings produced. Fluorine recovery in the slag was equal to, or higher than, that of fluorspar; fluorine losses to the scrubber water and solids were lower. The acidity of the scrubber water was somewhat neutralized. No difference was observed in furnace-refractory attack, as determined by the level of magnesia in the slag and visual inspection. The recovery of sodium in the slag, presumably as the oxide, significantly increased slag fluidity, suggesting that less than equivalent fluorine may be required. There was no contamination of the gray iron by the aluminum from the used potlining. Used potlining was completely satisfactory as a substitute for fluorspar in cupola ironmelting.

RI 8531. Insoluble Anodes for Electrowinning Zinc and Other Metals, by E. R. Cole, Jr., and T. J. O'Keefe. 1981. 25 pp. 8 figs. This Bureau of Mines investigation was prompted by the need for a stable anode for electrowinning metals, particularly zinc and copper, from acid solutions. The polarization behavior of Pb-Ag (1 pct Ag) anodes in H_2SO_4 and fluoride solutions was determined as the first step in the development of such an anode. A Luggin capillary, dc power supply, high-impedence

voltmeter, and other equipment standard to an electrochemical laboratory were used in this study. It was determined that during polarization, a relatively hard, stable coating of PbO_2 was formed on the surface of the lead-silver anode and the rate of formation of this coating was considerably enhanced by the presence of fluoride ions in solution. Subsequent investigations at the Bureau of Mines Rolla Research Center resulted in the development of a PbO_2-coated titanium (PbO_2-Ti) anode. Results of this effort were presented in Bureau of Mines Report of Investigations 8111. Additional data resulting from extensive testing of the PbO_2-Ti anodes, as well as process improvements and innovations, are included in this report. The anodes were considered generally unsatisfactory for zinc electrowinning because of lower conductivity, higher oxygen overvoltages, and shorter in-cell life as compared with the Pb-Ag anodes now being used in industry. However, the PbO_2-Ti anodes were used successfully to oxidize waste chromium solutions and to electrowin copper.

RI 8532. Beneficiation With Magnetic Fluids, by S. E. Khalafalla and G. W. Reimers. 1981. 21 pp. 8 figs. The Bureau of Mines has used colloidal solutions of magnetite in a magnetic field to segregate nonmagnetic materials such as nonferrous scrap metals and to concentrate precious minerals. Conventional magnetic separation relies on the inherent magnetic susceptibility of the material to be separated and may be designated as magnetic separation of the first kind. When the medium of separation rather than the separated particles are made magnetizable, a new system of gravity separation results. In this new magnetic separation of the second kind, a magnetic fluid rather than air or water acts as the separation medium. The same force that attracts magnetic objects in separations of the first kind also attracts the entire separation medium in separations of the second kind, thereby creating a reactionary force of equal magnitude in the opposite direction. This force, sometimes called the levitation force, can be made to segregate nonmagnetic particles in a flowing stream according to their specific gravity. The technique has been applied to segregate nonferrous metals from automobile and appliance shredders and mixed scraps. The system has also been used to upgrade diamondiferous jig concentrates from certain river gravels in order to facilitate the sorting and recovery of their diamond content.

RI 8533. Laboratory Investigation of Sulfurous Acid Leaching of Kaolin for Preparing Alumina, by A. E. Raddatz, J. M. Gomes, and M. M. Wong. 1981. 15 pp. 4 figs. In an attempt to develop technology to use domestic resources in place of imported bauxite, the Bureau of Mines investigated sulfurous acid leaching to extract alumina from kaolin. The process consists of leaching the calcined kaolin with a 30 wt-pct SO_2 solution at 60° C and 160 psig for 17 hours, filtering the leach slurry, precipitating monobasic aluminum sulfite from the filtrate at 110° C and 60 psig, and decomposing the sulfite in the spent liquid at 150° C and 55 psig to produce crude alumina. Purification of the crude alumina was accomplished using a modified Bayer process. Results from closed-circuit tests employing the sulfurous acid process showed that overall extraction of alumina from kaolin was 67 pct. Production of 1 ton of alumina would require 3.6 tons of calcined kaolin, 0.7 ton of sulfur dioxide, and 8.4 tons of water. After purification by a modified Bayer process, the alumina product contained the following impurities, expressed in weight-percent: Fe_2O_3, 0.009; S, 3.6; SiO_2, 0.07; TiO_2, 0.002; K_2O, 0.017; and P_2O_5, 0.03.

RI 8534. Direct Preparation of Phosphoric Acid From Intermediate-Grade Western Phosphatic Shale, by Philip C. Good, T. N. Goff, and C. B. Daellenbach. 1981. 12 pp. 2 figs. The Bureau of Mines investigated the feasibility of utilizing low-grade phosphatic shale as a feed for phosphoric acid production. Present practice in the phosphate mining operations of southeastern Idaho is to remove and either stockpile or waste low-grade phosphatic shales as the high-grade phosphate beds are selectively mined. Acid digestion studies were performed on uncalcined shale and on shale calcined to remove free carbon to determine phosphoric acid quality, yield, and amenability to filtration. The untreated shale, containing 21.4 pct P_2O_5, was digested with sulfuric acid in a single-tank reactor to yield phosphoric acid and gypsum residue. Although 96 pct P_2O_5 recovery was attained in digesting uncalcined shale, only the calcined product gave satisfactory filtration rates. Calcined shale yielded phosphoric acid recovery of about 93 pct of the contained P_2O_5. It was higher in impurities than commercially prepared acid derived from high-grade western phosphate rock. An acid filtration rate of 745 lb P_2O_5/ft^2/day was attained. This value is lower than the rate of 900 lb P_2O_5/ft^2 that is generally considered to be acceptable in industrial production of phosphoric acid from high-grade phosphate rock.

RI 8535. Treatment of Florida Surface Waters for Use in Phosphate Beneficiation, by D. A. Stanley, B. J. Scheiner, and P. Brown. 1981. 10 pp. 3 figs. The Bureau of Mines conducted laboratory-scale experiments to determine whether or not surface waters with high organic content could be purified sufficiently to be used to replace the natural high-quality deep well water currently being used in the silica flotation step of phosphate rock beneficiation. Waters abundant in organic matter were collected from two central Florida streams, flocculated with a cationic polyethylenimine polymer, and processed in a sand filter. This treatment removed most of the organic materials from the water. Untreated surface water, treated surface water, and distilled water were used to compare the flotation response of the acid insolubles in an amine flotation circuit. Surface water treated with PEI-1000 was shown to be as effective as distilled water for the acid-insoluble-flotation step. Flocculation and filtration can therefore produce water suitable for amine flotation of quartz, which would permit substitution of surface water for deep well water. 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 8536. High-Pressure Shrouded Water Sprays for Dust Control, by N. I. Jayaraman, F. N. Kissell, W. Cross, J. Janosik, and J. Odoski. 1981. 16 pp. 13 figs. High-pressure shrouded sprays were first tested on a bench to determine air-moving capability and dust collection efficiency. The bench-scale tests indicated that at 500 psi and above, the dust collection efficiency, when sampled downstream of a water eliminator, was about 99 pct for two types of nozzles. However, for the same water flow, the induced airflow was about three times greater in one type than in another. Since the only difference in the nozzles was the spray angle, this factor was

important in air movement through a shrouded spray. Full-scale model mine tests were then conducted to determine the reduction in dust concentration behind the line curtain and at the operator position produced by high-pressure sprays in a shroud. The shroud was mounted on top of the boom of a model continuous miner, and high-pressure (greater than 500 psi) sprays were installed inside the shroud. The inlet of dusty air to the shroud was open toward the face and the outlet toward the exhaust line curtain. The high-pressure sprays were compared with conventional sprays mounted at the head of the continuous miner and directing water toward the face. The difference at the operator position (opposite side of brattice) was significant in that, under certain conditions, with conventional sprays an increase in respirable dust concentration of 471 pct was noticed compared with dry operation due to rollback from face. High-pressure shrouded sprays, on the other hand, decreased the dust concentrations at the operator position (opposite side of brattice) by 28.2 pct.

RI 8537. Wear Properties of Electrodeposited Titanium Diboride Coatings, by D. R. Flinn, J. A. Kirk, M. J. Lynch, and B. G. Van Stratum. 1981. 30 pp. 13 figs. A newly developed chemical conditioning technique, which greatly simplifies the preparation of plating baths for the electrodeposition of titanium diboride (TiB_2) coatings, is described in this report. The new plating technique was used to prepare samples of titanium diboride (TiB_2) coatings on three types of substrate materials. These samples were then evaluated in both low- and high-speed wear-test programs to determine the wear resistance, microhardness, and adhesion of the coatings. In general, it was found that the wear resistance of the coatings is independent of substrate. Scanning electron micrographs have shown that the coating wear surfaces are very smooth, suggesting slow and continuous removal of the coating during the wear test (that is, adhesive wear). Adhesion between the coating and all substrates was excellent. Microhardness results show that the TiB_2 coating is harder than alumina, with a hardness value exceeding 5,000 kg/mm^2 measured in one test. The results of the wear tests show that TiB_2 coatings have relatively poor wear resistance compared with alumina in low-speed unlubricated sliding environments, but exhibit wear properties comparable with alumina in high-speed unlubricated sliding environments.

RI 8538. Suppression of Coal Dust Explosion by Water Barrier in a Conveyor Belt Entry, by I. Liebman and J. K. Richmond. 1981. 27 pp. 10 figs. The Bureau of Mines conducted experiments on coal dust explosion suppression. The investigation took place on a beltway in the double-entry of the Bureau's Experimental Mine. Using conditions that simulate those in a working mine, the investigation showed that a coal dust explosion can be readily initiated in a conveyor belt entry. Also, the explosion can spread into adjacent entries through opened crosscuts (stopping destroyed by explosion) to propagate for long distances even though the adjacent entries are rock dusted in compliance with regulations. Passive water barriers (water-filled tubs) were found to be effective in suppressing explosions on a beltway; however, barrier efficiency was reduced by opened crosscuts. The study indicated that the beltway barrier should be the distributed type consisting of continuous rows of water-filled tubs covering long distances along the entry. A plan is outlined for the installation of a water barrier system in a working coal mine for the protection of a beltway.

RI 8539. Hydrogen Sulfide Generation by Reaction of Natural Gas, Sulfur, and Steam, by S. R. Crane, Laird Crocker, and W. I. Nissen. 1981. 54 pp. 17 figs. One Bureau of Mines goal is to minimize the undesirable environmental impacts associated with industrial plants emitting waste gases containing SO_2. To help meet this goal, a regenerable flue gas desulfurization process was developed. This process, known as the citrate process, uses a buffered weak acid solution to absorb SO_2 from the waste gas. The absorbed SO_2 is reacted with H_2S to precipitate elemental sulfur and regenerate the solution for recycle. The H_2S feedstock for the process, if not otherwise available, may be produced by reacting two-thirds of the recovered elemental sulfur with natural gas and steam. Laboratory investigations and pilot plant operations were conducted by the Bureau to determine if H_2S from the natural gas, sulfur, and steam reaction was suitable for the citrate process. The laboratory investigations, in which an H_2S generator was integrated with other citrate process operations, provided a basis for design and operation of the pilot plant. The objective of the pilot plant was primarily to provide H_2S for the citrate process pilot plant at the Bunker Hill Co. lead smelter in Kellogg, Idaho. The design capacity of the pilot plant was 0.4 to 1.25 tons of H_2S per day. The operation demonstrated that (1) a 77- to 79-dry-volume-percent H_2S product could be produced from pilot-plant product sulfur, natural gas, and steam; (2) the product H_2S regenerated the SO_2-loaded citrate solution; and (3) under certain conditions over 95 percent of the natural gas could be converted to H_2S.

RI 8540. The Chemical Reactions of Sulfur in the Citrate Process for Flue Gas Desulfurization, by W. N. Marchant, S. L. May, B. W. Moore, and W. W. Simpson. 1981. 23 pp. 7 figs. The Bureau of Mines performed chemical research to elaborate details of sulfur chemistry pertaining to the citrate flue gas desulfurization process in which sulfur dioxide (SO_2), absorbed (as bisulfite ion) in a buffered sodium citrate solution, is reduced by hydrogen sulfide (H_2S) according to the overall reaction $2H_2S+HSO_3^-+H^+ \rightarrow 3S+3H_2O$. The rate-limiting step in the process was shown to be the reduction by H_2S of thiosulfate ($S_2O_3^{2-}$) that is formed as an intermediate. Pseudo first-order kinetic measurements were made at room temperature to retard the reaction sufficiently that adequate analysis was possible.

RI 8541. An Investment Mold for Titanium Casting, by E. D. Calvert. 1981. 35 pp. 16 figs. The Bureau of Mines, in its effort to promote greater utilization of domestically abundant materials, conducted research on an alternate mold material that has commercial potential for titanium investment casting. Using variations of the conventional lost wax molding process, investment shell molds were formed entirely of fused, calcia-stabilized ZrO_2 and a ZrO_2-forming binder. Optimization of binder/slurry properties, stucco grain size and distribution, and curing practices resulted in a structurally sound investment shell that was distortion free and thermally stable. Small titanium castings, weighing up to 10 pounds, were prepared in unheated molds by both static and centrifugal casting techniques. Microstructural examination of the castings revealed that mold fill and surface quality were enhanced by cen-

trifugal casting, although good results also were obtained from the statically poured molds. Microstructural and electron microprobe examinations showed that excessive, brittle case formation could be avoided by curing the dried shell molds in air for at least 2 hours at 1,400° C. Increasing curing temperature and time above these levels yielded added benefits. Molds fired in vacuum at 1,500° C for 4 hours yielded castings essentially free of case formation. The tensile properties of as-cast test specimens (no surface conditioning performed) and the chemical composition of representative metal samples showed that castings produced were comparable to Grades C-1 and C-2 unalloyed titanium. This indicated that no significant degradation of metal properties resulted from mold/metal interaction.

RI 8542. Three Bureau of Mines Optical Dust Probes, by Kenneth L. Cashdollar, Israel Liebman, and Ronald S. Conti. 1981. 26 pp. 19 figs. This report describes three types of optical dust probes that have been designed, built, and tested by the Bureau of Mines. Each of the probes measures dust cloud concentrations by the attenuation of light. The first is a single-path-length probe, the second is a double-path-length probe, and the third is a single-path-length probe that employs jets of air to keep the windows of the light source and detector free from dust coating. The theory of operation and the calibration procedures for each of the probes are described. The results of the Bureau's laboratory, mine, and field tests of the probes are also reported.

RI 8543. Behavior of Cadmium During Roasting of Zinc Concentrate, by Arne Landsberg, D. H. Yee, H. W. Leavenworth, Jr., and J. L. Henry. 1981. 17 pp. 10 figs. The Bureau of Mines has undertaken research to elucidate the chemistry involved in the efficient recovery and control of minor elements in base metal smelting operations. These elements should be effectively recovered not only because they have commercial value, but also because of their potential hazard to workers' health and the environment, if they are not controlled during processing. Cadmium, a minor metal in zinc ores, is the subject of this report. The roasting step of the complex zinc-smelting process was chosen for investigation because of the high potential for removing cadmium by volatilization during this primary stage. Commercial roaster feed materials were used to determine the sequence of reactions and the effect of these reactions on the volatilization of cadmium. Electron microprobe examination of both the commercial roaster product and oxidized sulfide solid solutions prepared in the laboratory showed that oxidized iron was of prime importance in preventing cadmium volatilization. The mechanism by which iron prevents cadmium volatilization is proposed, and a preheating technique is recommended for more effectively recovering cadmium prior to roasting.

RI 8544. Design Parameters for Oil Shale Waste Disposal Systems, by R. A. Bloomfield and B. M. Stewart. 1981. 38 pp. 17 figs. This report summarizes Bureau of Mines contract research on the disposal of retorted oil shale. A data base has been developed describing the physical-chemical properties, geotechnical engineering properties, and natural cementation characteristics of spent shale. Results of field compaction tests and seepage pond tests are presented, along with results of a partially saturated finite element seepage model used to predict infiltration and seepage rates. Preliminary engineering analyses are presented for underground disposal systems, which include material transport methods, and for a surface disposal system, which includes stability analyses.

RI 8545. Modified-Sulfur Cements for Use in Concretes, Flexible Pavings, Coatings, and Grouts, by W. C. McBee, T. A. Sullivan, and B. W. Jong. 1981. 24 pp. 12 figs. A family of modified-sulfur cements has been developed by the Bureau of Mines for the preparation of construction materials with improved properties. Various types of sulfur cements were prepared by reacting sulfur with mixtures of dicyclopentadiene (DCPD) and oligomers of cyclopentadiene (CPD). Durable cements were prepared with structural characteristics ranging from rigid to flexible. These cements were used to prepare corrosion-resistant materials for use in a wide variety of industrial applications where resistance to acidic and salt conditions is needed. These materials were prepared as rigid concretes, flexible pavings, spray coatings, and grouts. Production of modified-sulfur cements in a commercial-size plant was demonstrated.

RI 8546. Effect of Additives on Sintering of Silicon Nitride-Alumina-Aluminum Nitride Compositions, by B. W. Jong and H. Heystek. 1981. 14 pp. 4 figs. As part of the Bureau of Mines program to develop substitutes for critical and strategic materials for metallurgical applications, the Tuscaloosa Research Center has evaluated the effects of additives and starting materials on the sintering and strength properties of sialon (silicon-aluminum-oxynitride) compositions fabricated by conventional pressing and sintering techniques. Sintering and MOR (modulus of rupture) data were developed for sialon compositions produced from three components, Si_3N_4, Al_2O_3, and AlN. When doped with Y_2O_3 to aid in sintering, the highest MOR values were obtained with compositions containing between 20 and 30 mole-pct (Al_2O_3 + AlN). The effect of the crystalline phase of the Si_3N_4 and Al_2O_2 used in the three-component system on MOR was investigated. Alpha-Si_3N_4 and γ-Al_2O_3 were found to be the best starting materials. A sialon composed of 67.4 mole pct α-Si_3N_4 plus 32.6 mole-pct (γ-Al_2O_3 + AlN), doped with 5 wt-pct Y_2O_3, had MOR values at 25°, 1,200°, and 1,400° C of 40,300, 40,300, and 31,100 psi, respectively. Samples of this composition doped with Gd_2O_3, MgO, ZrO_2, and $ZrSiO_4$ also were evaluated. The $ZrSiO_4$-doped sialon had higher MOR values than Gd_2O_3-, MgO-, and ZrO_2-doped materials but lower MOR values than the Y_2O_3-doped sialon. The MOR values of $ZrSiO_4$-doped sialons were 25,000 and 25,900 psi, respectively, at 25° and 1,400° C.

RI 8547. A Mixed Kinetics Dump Leaching Model for Ores Containing a Variety of Copper Sulfide Minerals, by B. W. Madsen and M. E. Wadsworth. 1981. 44 pp. 14 figs. To help maintain an adequate supply of minerals to meet national economic and strategic needs, the Bureau of Mines developed a mathematical model that describes acidic ferric sulfate leaching of copper from sulfide ores The leaching model can aid in maximizing minerals and metals recovery from primary sources by giving operators and management a better understanding of the copper leaching process. This will aid in improving dump leaching operations. The model is based on a steady-state approximation of the continuity equation for diffusion of ferric ions in the rock pores and the intrinsic leaching kinetics of the various sulfide mineral particles. Ore characteristics included in

the model were ore particle-size distribution, particle shape, grade, mineral content, mineral particle size, porosity, and tortuosity. The continuity equation was used with ferric ion concentration gradients and a fixed value for the diffusion coefficient. Except for effective diffusivity, each of these factors was either measured experimentally or estimated from theoretical considerations. The effective diffusivities were determined by fitting calculated leaching curves with experimental leaching data. Vertical variations in leach solution composition and temperature within a dump are not considered in this model. The model accurately predicted copper extractions for several large-scale tests during nearly 500 days of leaching.

RI 8548. An Apparatus and Procedure for Calibrating a Water Vapor Analyzer in the 0.1- to 15-ppm Range, by Harold L. Rhodes. 1981. 8 pp. 5 figs. The Bureau of Mines has developed a quantitative method to determine water vapor in helium in the range of 0.1 to 15 ppm by volume. This method uses the quantitative chemical reaction of H_2O with CaH_2, which produces 1 mole of hydrogen for each mole of H_2O in the sample. A gas chromatograph is then used to determine the concentration of hydrogen in the product. The precision of the H_2O analysis is ± 0.05 ppm at a concentration of 1 ppm. This method is used to calibrate a commercial platinum-phosphorus pentoxide ($Pt\text{-}P_2O_5$) electrolytic water vapor analyzer that has an improved inlet system and digital voltmeter readout. Research at the Tuscaloosa Research Center is carried out under a cooperative agreement between the Bureau of Mines, U.S. Department of the Interior, and the University of Alabama.

RI 8549. Reduction Roasting and Beneficiation of a Hematitic-Geothitic Taconite, by R. E. Peterson and A. F. Colombo. 1981. 20 pp. 6 figs. A reduction roasting-magnetic separation-flotation process for beneficiating oxidized taconite from the western Mesabi iron range in Minnesota was evaluated in a Bureau of Mines research program to insure an adequate supply of raw materials for future iron-making and steelmaking needs. The research was performed on a sample containing 35.4 pct iron and representing a deposit of approximately 2 billion tons of raw materials. An average of 1,419 lb of oxidized taconite and 37 lb of lignite reductant per hour were fed to a 35-foot rotary kiln in which the iron oxides were converted to artificial magnetite. The kiln was heated with pulverized lignite and natural gas. Most of the dust collected from the kiln exhaust was pelletized and recycled to the kiln. Magnetic separation and cationic flotation of the roasted material in a 900-lb/ft pilot plant produced a concentrate analyzing 67.9 pct iron and 4.9 pct silica and containing 69.2 pct of the iron in the kiln feed.

RI 8550. Recovery of Aluminum Hydroxy Sulfate From Aluminum Sulfate Solution by High-Temperature Hydrolysis, by D. E. Shanks, J. A. Eisele, and D. J. Bauer. 1981. 10 pp. 4 figs. As part of its program to lessen dependence on foreign bauxite as the Nation's primary source of cell-grade alumina, the Bureau of Mines is investigating sulfuric acid (H_2SO_4) leaching procedures for the recovery of alumina from domestic aluminous materials. The successful application of a H_2SO_4 leaching process depends on the recovery of the aluminum values in an easily washed and filtered form, containing a minimum of water to be driven off in the subsequent calcination step. This goal was met by the high-temperature hydrolysis of simulated aluminum sulfate [$Al_2(SO_4)_3$] leach liquor. Crystalline, insoluble aluminum hydroxy sulfate [$Al(OH)SO_4$], which had a water-to-alumina mole ratio of 1:1, was produced. Eighty-six percent of a solution containing 127 g of $Al_2(SO_4)_3$ per liter and 76 pct of a solution containing 336 g of $Al_2(SO_4)_3$ per liter was hydrolyzed to insoluble aluminum hydroxy sulfate by autoclaving for 1 hr at 320° C and rapidly quenching to room temperature. Higher operating temperatures were precluded by corrosion of the autoclave. The yield of aluminum in the hydrolysis product increased with the increasing hydrolysis temperature and decreasing $Al_2(SO_4)_3$ concentration.

RI 8551. Structure Study of a CF_2BR_2-Inhibited Methane Flame. Effect of CF_2BR_2 on Composition, Net Reaction Rates, and Rate Coefficients, by J. F. Papp, C. P. Lazzara, and J. C. Biordi. 1981. 32 pp. 22 figs. The microstructures and a CF_2Br_2-inhibited methane flame and its uninhibited analog have been determined using molecular beam-mass spectrometry. The slightly lean flames were stabilized on a cooled porous plug burner at reduced pressure. Composition profiles of stable, intermediate, and radical species and temperature profiles revealed the following inhibition effects; a shift of the primary reaction zone to higher temperatures, a higher maximum flame temperature, an increase in the CH_3 concentration, and a reduction in the H_2CO, H, O, and OH concentrations. Kinetic analyses of the data yielded rate coefficients at flame temperatures for the reactions $H + CH_4 \rightarrow CH_3 + H_2$, $H + O_2 \rightarrow OH + O$, $CO + OH \rightarrow CO_2 + H$, and $CH_3 + O \rightarrow H_2CO + H$. CF_2Br_2 is judged to decay by thermal decomposition and abstraction reactions.

RI 8552. Beneficiation of Western Mesabi Range Oxidized Taconites. A Comparison of the Anionic and Cationic Flotation Systems and an Evaluation of Potential Iron Ore Reserves, by Howard D. Jacobs. 1981. 21 pp. 6 figs. A bulk sample of oxidized taconite taken from the western Mesabi Range was evaluated by the Bureau of Mines using the Bureau-developed selective flocculation-desliming-cationic (or anionic) flotation process. The raw ore sample containing 32.3 pct Fe was treated by both cationic and anionic flotation. Using the cationic system the concentrates averaged 37.2 wt-pct of the feed and contained 62.8 pct Fe and 4.7 pct SiO_2 with an iron recovery of 72.3 pct. With the anionic system, concentrates averaged 37.7 wt-pct of the feed and contained 63.0 pct Fe and 5.3 pct SiO_2 with an iron recovery of 73.5 pct. A comparison of reagent costs showed that the cationic process cost 144.1 cents per long ton of crude ore and the anionic process 178.7 cents per long ton of crude ore. Reclaimed water comprised 86 pct of the total water requirement for anionic flotation and 88 pct for cationic flotation. The ore used in this study was one of three samples representing about 3.25 billion tons of oxidized taconite containing from 32 to 36 pct feed iron. Previous study had indicated that selective flocculation-desliming-cationic flotation would produce concentrates from the other two samples of 61.7 pct Fe and 5.1 pct SiO_2 at 67-pct Fe recovery, and 63.5 pct Fe and 4.3 pct SiO_2 at 85-pct Fe recovery. By developing a successful treatment for these ores, the Bureau has insured the availability of technology for processing an amount of raw iron ore which, by itself, would supply U.S. iron needs for 50 to 75 years at expected consumption rates.

RI 8553. Beneficiation of Potential Platinum Resources From Southeastern Alaska, by D. C. Dahlin, A. R.

Rule, and L. L. Brown. 1981. 14 pp. 2 figs. The Bureau of Mines conducted laboratory batch beneficiation tests on samples from four potential platinum resources in southeastern Alaska to concentrate platinum and other precious metals. This investigation was done as part of the mission of the Bureau to insure an adequate supply of minerals to meet the Nation's needs. Petrographic studies and beneficiation methods including gravity concentration, froth flotation, and magnetic separation were used to determine mineral association and to attempt to concentrate the platinum values with a primary mineral value such as chromite, copper sulfide, or magnetite. A high-graded sample from the Salt Chuck copper sulfide deposit yielded the best platinum-group metal concentrate; the maximum grade attained was 0.04 oz Pt and 1.5 oz Pd per ton of high-grade copper sulfide concentrate. The other samples yielded low-grade mineral concentrates with low platinum-group values, and/or the platinum-group metals did not concentrate with the primary mineral value.

RI 8554. Copper Recovery From Primary Smelter Dusts, by W. E. Anable, J. I. Paige, and D. L. Paulson. 1981. 19 pp. 8 figs. The Bureau of Mines researched methods for recovering copper from cyclone and electrostatic-precipitator dusts of primary copper smelters as part of its program to maximize minerals and metals recovery from primary and secondary domestic resources. Small-scale studies showed that use of 110 pct stoichiometric sulfur and 123 pct stoichiometric carbon, based on producing a 40-pct copper-iron matte, resulted in the recovery of 95 pct of the copper contained in the dust. Typical mattes contained less than 10 pct of the arsenic, 30 pct of the bismuth, and 45 pct of the antimony and tin contained in the dust. Matte was converted to blister copper by injecting up to 200 pct of the stoichiometric oxygen requirement over a period of 2 to 3 hours. Up to 76 pct of the copper contained in the dust was recovered as a crude blister copper containing about 2 pct arsenic, 0.5 pct antimony, and less than 0.1 pct bismuth and tin. A matte-white metal product resulted from carbothermically reducing dust with coal, lime, and silica. Up to 95 pct of the copper was recovered in the combined product.

RI 8555. The Geologic Character of Some Coal Wants at the Westland Mine in Southwestern Pennsylvania, by Noel N. Moebs. 1981. 25 pp. 25 figs. The coal wants at the Westland Mine in southwestern Pennsylvania consist chiefly of elongated, sandstone-filled channels with slickensided basal contacts. Tentatively identified as washouts, these channels are about 1,000 feet long and 300 feet wide, are erratic in occurrence and trend, and are difficult to delineate from the customary core drilling pattern. Roof conditions are hazardous adjacent to the washout contact, but roof stability is generally unaffected greater than 30 feet away.

RI 8556. Consolidation of an Iron-Base Superalloy by Powder Metallurgy Techniques, by J. F. McIlwain, and L. A. Neumeier. 1981. 22 pp. 16 figs. As part of its goal to minimize the requirements for critical materials, the Federal Bureau of Mines has investigated the consolidation of an iron-base superalloy (20 pct Cr, 5 pct each Ni and Mn, 1 pct each C, W, Mo, and Cb, and the balance Fe) and its modifications by powder metallurgy (P/M) techniques. Vacuum-atomized, prealloyed powder was used. Consolidation was by sintering of cold-pressed alloy powder, or by forging plus rolling or extrusion of canned powder. Several commercial lubricants were evaluated in the pressing operation. At 50-tsi compacting pressure with up to 3 wt-pct lubricant, green strengths did not exceed 1,000 psi. Powder sintered just below the solidus temperature attained a tensile strength of 69,000 psi and 4 pct elongation. Liquid-phase sintering produced higher densities, lower tensile strengths, and nil ductibility. Canned powder was forged and rolled at 1,200° C, yielding a 100-hr rupture strength of 9,800 psi at 815° C and a room-temperature tensile strength of >130,000 psi at 6 pct elongation. Heat treatment of modified P/M iron-base alloy containing 0.63 pct C resulted in a 100-hr ruptured strength of 17,000 psi. Oxidation resistance at 805° to 815° C of the forged and rolled P/M iron-base alloy was similar to that of the cast iron-base alloy and superior to conventional stainless steels.

RI 8557. Ceramic Mold Inserts for Use in Ferrous Diecasting, by E. G. Davis and G. V. Sullivan. 1981. 27 pp. 16 figs. A research program to evaluate the use of ceramic die inserts for ferrous diecasting was initiated by the Bureau of Mines at its Tuscaloosa Research Center. Data were compiled from the literature to characterize selected ceramic materials with respect to thermal properties, thermal-shock resistance factors, chemical reactions with molten metals, and processes required to form die components. With this information and a computer model developed for predicting temperature and stress patterns induced in ceramic materials during simulated ferrous diecasting operations, 27 candidate materials were evaluated. After evaluation, only 15 were considered for testing in an apparatus constructed to immerse the ceramic specimens in molten cast iron. Of these, 13 were tested in a modified testing unit in which cast iron was poured onto the specimens. These tests resulted in the selection of three materials for further testing: boron carbonitride (50 pct B_4C:50 pct BN), boron nitride-grade M (BN-M, 40 pct BN, 60 pct SiO_2), and pyrolytic boron nitride (PBN). Tests in a gravity-flow die unit showed that PBN was thermal-shock resistant and could be used in diecasting of ferrous metals. Research at the Tuscaloosa Research Center is carried out under an agreement between the Bureau of Mines, U.S. Department of the Interior, and the University of Alabama.

RI 8558. Evaluation of Synthetic Fluorspar in BOF Slags, by H. W. Kilau, V. R. Spironello, I. D. Shah, and W. M. Mahan. 1981. 28 pp. 9 figs. The Bureau of Mines evaluated synthetic fluorspars as substitutes for natural fluorspar in basic oxygen steelmaking using a high-temperature rotational viscometer and a quarter-ton basic oxygen furnace (BOF). Considerable variation in stability and BOF slag fluidizing properties were found when using the initial synthetic products, but improved synthesis methods produced synthetic fluorspars that were generally comparable to natural fluorspar in laboratory testing. Trials in the furnace showed the synthetic products to be operationally the equivalent of natural fluorspar. Higher sulfur and phosphorus contents in some of the synthetic materials did not adversely affect the steel chemistry. Analyses of wet scrubber samples showed evidence that the pelletized synthetic fluorspars experienced greater physical and chemical disintegration than did natural fluorspar. It was also found that operation of a BOF without fluorspar is possible when making

low-carbon steels because iron oxide is intrinsically generated as the slag fluidizer.

RI 8559. Polymeric Concentration Determined by Drag Reduction, by Jalna R. Zatko. 1981. 11 pp. 6 figs. The Bureau of Mines has developed and constructed an apparatus that is capable of measuring concentrations of high-molecular-weight polymers in solution at 10 ppm and less. A means for determining low concentrations of polymeric solutions was devised that was independent of slight fluctuations in solvent quality in order to measure polymers in effluent prior to recycling of the recovered solution. The concentrations of polymers are related to a measured pressure drop observed during turbulent flow of the solution. Low concentrations of polymers of ethylene oxide and acrylamide (frequently used as flocculants for clay waste systems) in aqueous and salt solutions have been successfully measured on the apparatus constructed by the Bureau. Research at the Tuscaloosa Research Center is carried out under an agreement between the Bureau of Mines, U.S. Department of the Interior, and the University of Alabama.

RI 8560. The Removal of Iron From Aluminum Chloride Leach Liquor by Solvent Extraction, by Roy T. Sorensen, Earle B. Amey III, and Dwight L. Sawyer. 1981. 28 pp. 12 figs. As part of its mission to maintain an adequate supply of minerals to meet national needs and maximize mineral production from domestic sources, the Bureau of Mines is investigating the recovery of alumina by hydrochloric acid leaching of kaolinitic clay. Most iron impurities are leached from the clay along with the alumina and must be removed before or during crystallization to aluminum chloride hexahydrate. The thermal decomposition step then provides an alumina product of acceptable iron analysis. Miniplant studies of a Bureau-developed solvent extraction technique, using a tertiary amine in kerosine diluent, have demonstrated that the iron content in aluminum chloride leach liquors can be reduced to levels of less than 0.007 wt-pct (7 ppm), expressed as Fe_2O_2. Entrained and dissolved organic matter in the purified pregnant leach liquor from the solvent extraction circuit can be reduced to less than 2 ppm by using a fabric-packed coalescer and subsequent activated carbon treatment. Investigators discovered that a steady buildup of zinc accumulated in the solvent phase within the extraction circuit, proportional to the amount of leach liquor treated. The solvent phase zinc analysis increased by 0.01 wt-pct ZnO for each 1,000 gal of pregnant leach liquor purified.

RI 8561. Recovery of Copper and Associated Precious Metals From Electronic Scrap, by H. B. Salisbury, L. J. Duchene, and J. H. Bilbrey, Jr. 1981. 16 pp. 8 figs. As a part of a research program designed to help minimize national requirements for new mineral commodities by maximizing recovery of metals from domestic secondary resources, the Bureau of Mines investigated the development of economic methods for recovering copper and associated metals from complex electronic scrap. Three types were selected for research: (1) multiple-pin plugs and connectors, (2) obsolete aircraft radio assemblies, and (3) the magnetic fraction of shredded electronic scrap furnished by the Bureau's Avondale Research Center. The plugs and connectors, after incineration to remove plastic components and melting, yielded a brittle ingot, as did the internal portion of the radio assemblies. The brittle ingots were ground to minus 35-mesh for processing, and the magnetic material was used in the as-received condition. A process using pretreated or raw scrap as a copper precipitant in various concentrations of acidulated copper sulfate solution was developed as a means of effecting an initial separation and upgrading in the form of high-grade cement copper containing all or most of the precious metals.

RI 8562. Characterization and Beneficiation of Phosphate-Bearing Rocks From Northern Michigan, by L. L. Brown, A. R. Rule, and C. B. Daellenbach. 1981. 16 pp. 10 figs. 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.

RI 8563. Recovery of Byproduct Heavy Minerals From Sand and Gravel Operations in Oregon and Washington, by G. M. Martinez, J. M. Gomes, and M. M. Wong. 1981. 14 pp. 4 figs. The Bureau of Mines has investigated methods for the recovery of byproduct heavy minerals from sand and gravel operations in Oregon and Washington. These heavy minerals are not currently recovered except for gold in a few areas. The recovery of byproduct heavy minerals would provide a domestic source of minerals presently imported, and a more efficient use of domestic resources would be accomplished. Samples from more than 40 locations were treated by gravity separation to yield heavy mineral concentrates (black sands). Magnetite, ilmenite, zircon, rutile, chromite, platinum-group minerals, radioactive minerals, and gold were identified in the concentrates. Individual zircon, ilmenite, chromite, magnetite, and gold products were recovered from selected concentrates by low- and high-intensity magnetic, high-tension, and heavy-medium separation techniques. The recovery for the individual mineral products ranged from 67 to 95 pct.

RI 8564. Factor of Safety Charts for Estimating the Stability of Saturated and Unsaturated Tailings Pond Embankments, by D. R. Tesarik and P. C. McWilliams. 1981. 97 pp. 173 figs. The factor of safety, the traditional measure of stability for earth embankments, is graphically presented in factors of safety charts in this Bureau of Mines report. Factor of safety contours are drawn for homogeneous earth embankments for two contrasting situations: (1) no phreatic surface and (2) a phreatic surface that assumes 10-pct freeboard. The factor of safety can be read directly from the charts if the physical properties of the soil and the geometry of the em-

bankment are known. The curves provide a quick first approximation of the "most stable" and "least stable" condition of the embankment. The Simplified Bishop Method was used for the safety factor calculations, and a sequence of least squares curve fitting steps was used to present the factor of safety in final chart form.

RI 8565. Corrosion Resistance of Materials in the Aqueous Hydrochloric Acid Environments Associated With the Recovery of Aluminum From Kaolinitic Clays, by B. S. Covino, Jr., M. Rosen, and W. D. Riley. 1981. 28 pp. 10 figs. The Bureau of Mines has conducted a laboratory and field corrosion testing program to determine materials of construction for the leaching and gas-sparging crystallization environment of the clay-HCl process in order to more fully utilize the alumina from domestically available kaolinitic clays. Laboratory tests were used to determine the corrosion rates of 22 metals and alloys by weight-loss measurements in these two environments of the process. The results of this laboratory study were used both to suggest metals and alloys for field testing and to determine the effect of the individual solution components on the corrosion behavior of the metals and alloys. Results from the field tests were used to recommend Ta, Ta-2.5W, and Ta-10W for construction of the agitators for the leaching process. The metals and alloys recommended for construction of the gas-sparging crystallizer heat exchangers were Ta, Ta-2.5W, Ta-10W, Nb, Nb-1Zr, Nb-3Zr, Nb-28Ta-10W-1Zr, Nb-10Hf-1Ti, and Zr for the first stage and Ta, Ta-2.5W, Ta-10W, Nb-28Ta-10W-1Zr, Nb, Nb-10Hf-1Ti, and Zr for the second stage.

RI 8566. An Algorithm for Determining Debye Temperatures, by R. P. Beyer. 1981. 5 pp. As part of its thermodynamic investigations of mineral compounds, the Bureau of Hines has written an algorithm based on Newton's method for solving for the characteristic Debye temperature of a compound, from heat capacity and temperature data. A listing of a FORTRAN IV program based on this algorithm, for calculating Debye temperatures given heat capacities or for calculating heat capacities given Debye temperatures, is available from the author upon request.

RI 8567. Evaluation of the Seismic System for Locating Trapped Miners, by John Durkin and Roy J. Greenfield. 1981. 55 pp. 33 figs. This report discusses the configuration and system deployment for the postdisaster surface seismic system for detecting and locating trapped miners. It analyzes the results of 15 field tests to define a signal model, background noise levels, and subarray performance. A waveform modeling procedure is described and compared with observed waveforms. The resulting similarity indicates that the major factors affecting the signal amplitude, waveform, and spectral character are understood. A model is presented which gives the signal amplitude as a function of source type, source depth, and horizontal offset between source and receiver. Using this model a curve is presented which gives the range at which a signal will be detected for different signal and noise levels. Finally, and most important relative to the mission of the system, the ability of the system to detect signals on one or more subarrays is put into a probabilistic framework. For a strong source it is almost certain that a subarray directly over the source will detect the signal. After signal processing, it is highly likely that signals will be detected on sufficient subarrays to locate the trapped miner. Location errors have been found to be less than 100 ft in the majority of cases. Techniques have been used that can reduce the location errors to this level even when soil layer variation between subarrays is severe.

RI 8568. Automatic and Continuous Transducer-Drift Compensator for Endpoint Detection Systems, by Charles A. Seitz and George M. Lucich. 1981. 9 pp. 5 figs. This Bureau of Mines report describes an automatic and continuous transducer-drift compensator. The compensator formed a part of the instrumentation used to indicate the saturation by hydrogen of a cryogenic, adsorption column. It has a variable delayed-response characteristic and will respond only to signals having rise times faster than component drift times. Zero drift due to varying ambient conditions and component aging is nullified. Equations relating the output as a function of the input signal are given.

RI 8569. Water Jet Perforation. A New Method for Completing and Stimulating In Situ Leaching Wells, by G. A. Savanick and W. G. Krawza. 1981. 30 pp. 18 figs. The Bureau of Mines has designed, fabricated, and field tested a water jet cutting device capable of perforating nonmetallic well casings for the purpose of completing or stimulating in situ uranium leaching wells. The device is lowered into the wellbore, where it issues a high-velocity water jet that penetrates either a polyvinyl chloride or fiberglass casing, cement, and from 1 to 4 feet into the surrounding uraniferous sandstone. The resulting perforations allow leaching solution to pass between the sandstone and the wellbore. This report describes the water jet perforator, tells how it is used, presents cost data, and discusses the results of laboratory and field tests. The tests were designed to (1) determine the optimum operating conditions for water jet perforation, (2) assess the effects of changes in these conditions, (3) evaluate the performance of the water jet perforator under actual conditions, and (4) compare this method with other methods of well completion. These tests showed that water jet perforation is superior to conventional well completion methods for selectively achieving communication between the wellbore and adjacent sand while maintaining sand control, for restoring permeability lost through wellbore damage, for stimulating poorly performing wells for completing wells with casings that have inside diameters as small as 2 inches, and for extending the effective well diameter.

RI 8570 Process for Recovering Chromium and Other Metals From Superalloy Scrap, by J. J. deBarbadillo, J. K. Pargeter, and H. V. Makar. 1981. 73 pp. 27 figs. This Bureau of Mines report describes a process for recovering chromium and other metals from superalloy scrap. Laboratory-scale experiments were conducted to test a complex flowsheet utilizing a wide range of extractive metallurgical operations. The novel basis for the process is the formation of a sulfide matte in which chromium is concentrated in a discrete chromium sulfide phase. Mineral processing and hydrometallurgical procedures are used to separate chromium sulfide from the other matte constituents. The products of the process are a chromium-nickel alloy suitable for reuse in the superalloy industry, electrolytic nickel, electrolytic cobalt, and iron-molybdenum residue. Recovery of the principal elements contained in the scrap is chromium—93 percent, nickel—99 percent, cobalt—96 percent, and molybdenum—92 percent.

RI 8571. Pyrometallurgical Recovery of Chromium From Scrap Metals: Laboratory Studies, by Charles L. Kusik, Krishna Parameswaran, David J. Kinneberg, and Harry V. Makar. 1981. 41 pp. 10 figs. As part of an effort to establish processes that could be exploited in case of adverse changes in international chromium production and trading patterns, this study was sponsored by the Federal Emergency Management Agency (formerly the Federal Preparedness Agency) through the Bureau of Mines, to experimentally determine the feasibility of recovering chromium from critical scrap metals containing significant quantities of this element. Based on a conceptual pyrometallurgical chromium recovery flowsheet developed at Arthur D. Little, Inc., the experimental program described in this report demonstrated key process steps for the recovery of chromium as ferrochromium in a batch process. The process involves oxidation of chromium into a slag phase, subsequent separation of the slag phase from the remaining metal, followed by reduction of chromium from the slag phase to produce ferrochromium.

RI 8572. Beneficiation of a Hematitic Taconite by Reduction Roasting, Magnetic Separation, and Flotation, by R. E. Peterson and A. F. Colombo. 1981. 13 pp. 5 figs. The Bureau of Mines has undertaken beneficiation investigations on samples representing large tonnages of oxidized taconites in order to develop and evaluate applicable technologies for producing iron oxide concentrates from these materials. Information derived from the investigations can be used to expand the domestic iron raw-materials base and to establish the impact these taconite deposits may have on future national iron ore requirements. This report describes a process that includes reduction roasting, magnetic separation, and flotation, applied to a western Mesabi Range sample taken near Coleraine, Minn. The sample contained 36.8 pct iron and 46.0 pct silica, and represented 0.5 to 1 billion tons of crude material. An average of 962 lb/hr of oxidized taconite was roasted with 33 lb/hr of lignite in a 35-foot-long rotary kiln. Pulverized lignite and natural gas maintained the kiln operating temperature at 850° C. The roasted taconite was beneficiated by magnetic separation and cationic flotation in a 900-lb/hr pilot plant and yielded a product analyzing 68.1 pct iron and 4.6 pct silica, and containing 82.4 pct of the iron in the kiln feed.

RI 8573. Modification of a Commercial Atomic Absorption Spectrophotometer for Cold-Vapor Determination of Mercury, by Joseph A. Perry, Raymond F. Farrell, and Alick J. Mackie. 1981. 11 pp. 4 figs. One goal of the Bureau of Mines is to develop technology to insure a dependable supply of minerals to the United States. To support this goal, the Bureau's Albany Research Center has modified a commercial atomic absorption spectrophotometer to rapidly determine trace levels of mercury by cold-vapor atomic absorption spectrophotometry. Such diverse materials as ores, mill products, stream water, sediments, and flue dust have been analyzed. A very high dynamic range of 0.2 ng/ml to 1 μg/ml of mercury in solutions is routinely analyzed by this instrument.

RI 8574. A Pyrometallurgical Method for Processing Ni-Cd Scrap Batteries, by Donald A. Wilson and Harry V. Makar. 1981. 14 pp. 3 figs. As part of a continuing effort to maximize metal recovery from domestic secondary resources, the Bureau of Mines investigated a process for recovering the metallic portion of scrap alkaline batteries. A pyrometallurgical method for recovering nickel and cadmium from Ni-Cd scrap batteries previously developed on a laboratory scale, was scaled up to 25- and 43-pound charges. The method employed reduction and/or decomposition in a retort using a minimum of 2.5 percent carbon as a reductant. Metallic cadmium was distilled at atmospheric pressure and a minimum of 900° C. Purity of the recovered cadmium was 99.8 percent minimum and the nickel-iron residue contained less than 0.02 percent cadmium.

RI 8575. Geologic Factors in Predicting Coal Mine Roof-Rock Stability in the Upper Kittanning Coalbed, Somerset County, Pa., by A. T. Iannacchione, J. P. Ulery, D. M. Hyman, and F. E. Chase. 1981. 41 pp. 28 figs Roof-rock instability in advancing sections of underground coal mines is a major contributing factor to accidents resulting in fatalities and injuries. Such roof-rock conditions can also result in loss of production due to additional cleanup time and increased amounts of reject material. The Bureau of Mines is investigating fundamental geologic factors affecting coal mine roof-rock instability in order to develop techniques to predict zones of potential unstable roof-rock. Two distinct directional trends of unstable shale roof-rock in a mine working the Upper Kittanning Coalbed are delineated: one trend is associated with the sandstone-shale transition zone, the other with a fault system. The unstable shale roof-rock associated with the transition zone, a consequence of differential compaction, is comprised of slickensided roof-rock. Whereas, the unstable shale roof-rock associated with the fault system, a consequence of structural deformation of the strata, is comprised of fault planes. These faults, small in comparison to the sandstone-shale transition zone, are difficult to delineate with a standard drilling program. Trends of the transition zone associated with the sedimentary facies change are projected into unmined portions of the coalbed with the aid of exploration core data.

RI 8576. Fluorine and Uranium in Phosphate Rock Processing and Waste Materials, by Benjamin W. Haynes, Gary W. Kramer, and July A. Jolly. 1981. 17 pp. 3 figs. Materials from phosphate rock mining and processing were analyzed for fluorine and uranium content as part of the Bureau of Mines program to more effectively recover resources from mining and mineral processing reject materials. The analysis of both feed and waste materials generated in the beneficiation and acidulation of phosphate rock was performed to obtain information on the disposition and concentration of these elements in phosphate rock processing streams. Fluorine was determined by a distillation-titration method and by ion chromatography. Uranium was determined by the dibenzoylmethane (DBM) method, the reliability being confirmed by roundrobin analysis of samples within Bureau of Mines research centers. National Bureau of Standards (NBS) Standard Reference Material (SRM) 120b-Phosphate Rock was also analyzed for fluorine and uranium to verify procedures and results. Fluorine values ranged from 0.3 wt-pct in gypsum filter cake to 3.7 wt-pct in phosphate rock concentrate. Uranium ranged from less than 5 μg/g in gypsum filter cake to 200 μg/g in a dried clay slime.

RI 8577. Methane Draining Study Using an Underground Pipeline, Marianna Mine 58, by L. J. Prosser, Jr., G. L. Finfinger, and J. Cervik. 1981. 29 pp. 26 figs. The Bureau of Mines has completed an underground degasification project in which an

underground piping system was used to transport methane from the coalbed to the surface. In a 10-month period four horizontal holes were drilled to an average depth of 1,450 feet. All four holes were surveyed vertically and azimuthally. In 991 days of degasification, 255 MMcf of gas was drained from the coalbed. The underground piping system proved to be a safe and effective means of transporting methane from the coalbed to the surface.

RI 8578. A Method for Determining Helium in Water, by Philip W. Holland. 1981. 17 pp. 4 figs. The Bureau of Mines has developed a method for determining helium in water for use in sampling and analyzing surface and subsurface waters for geochemical survey work. The accuracy of the analytical method is within ±10 percent for samples containing above 20×10^{-8} cm^3 He (STP)/cm^3 H_2O. The minimum detectable helium-in-water concentration is calculated to be 2×10^{-8} cm^3 He (STP)/cm^3 water. Water samples are collected in 500-cm^3 stainless steel cylinders. The dissolved gases are extracted into a cylinder of equal volume containing a known quantity of neon. The resulting gas mixture is subsequently analyzed for helium and neon-21 by mass spectrometry. The volume of helium in the sample is calculated from the mass spectrometric determination of the helium-to-neon-21 ratio, the known quantity of neon used, and the extraction efficiency of helium.

RI 8579. Analysis of Pillar Stability on Steeply Pitching Seam Using the Finite Element Method, by Nicholas P. Kripakov. 1981. 33 pp. 18 figs. The U.S. Bureau of Mines examined the applicability of existing material models to solve practical geotechnical mining-related problems by solving a yielding pillar stability problem considering confining effects on strength. Numerical difficulties normally encountered with modeling strain softening behavior were eased with a simplified computational procedure using a quasi-elastic approach to account for residual strength after initial failure. Although in agreement with a confined-core pillar design method using actual mine conditions that include mine layout geometry, overburden geology, and rock properties of the deposit and surrounding structure, the results cannot be verified because measured field data are not available at this writing.

RI 8580. Extracting Uranium From Carbonaceous Ores, by L. E. Schultze, D. J. Bauer, and M. T. Morimoto. 1981. 12 pp. 3 figs. As part of its goal of maintaining an adequate supply of minerals to meet national economic and strategic needs, the Bureau of Mines devised a processing sequence for recovering uranium from carbonaceous ores. Uranium extractions of 97 pct were obtained by contacting the ore with a solution containing 400 grams of ferric sulfate hydrate in 200 ml water for 3 hr at boiling temperature (96° C). Uranium was recovered from the leaching solution by solvent extraction with tri-issooctyl amine. The barren ferric sulfate solution was recycled to the leaching system. The leaching process resulted in no detectable dissolution of carbonaceous material from the ore. Work on the project was terminated in 1978 because of a transfer of responsibility to the U.S. Department of Energy.

RI 8581. Fine Coal-Refuse Slurry Dewatering, by R. R Backer and R. A. Busch. 1981. 18 pp. 11 figs. The Bureau of Mines, in cooperation with Washington Irrigation and Development Co. (WIDCO), evaluated the dewatering of fine coal-refuse slurry using chemicals and various types and combinations of drains in natural earth impoundments. About 40 lb of lime and 2 lb of polymer per ton of dry solids were mixed with the underflow from the preparation-plant thickener. Clear, free water was immediately liberated from the slurry. The percent solids by weight of the slurry increased from about 17 to 30 immediately, and after 5 days increased to 45 wt-pct. This indicates a threefold reduction in total volume after 5 days from 172 cu ft/ton solids originally to 56 cu ft/ton solids.

RI 8582. Recovery of Principal Metal Values From Electrolytic Zinc Waste, by T. L. Hebble, V. R. Miller, and D. L. Paulson. 1981. 12 pp. 7 figs. The Bureau of Mines investigated a hydrometallurgical procedure to recover Co, Ni, and Cu from an electrolytic zinc industrial copper filter cake. The copper filter cake is presently unmarketable or of low value because economic and environmentally acceptable processing technology is lacking. Research by the Bureau of Mines has developed a multistage process for recovering or recycling over 93 pct of the Zn, Cd, Cu, Co, and Ni from this material. The stages involved are (1) wet sizing, (2) H_2SO_4 leaching of undersized material, (3) H_2SO_4-MnO_2 leaching of H_2SO_4 leach residue, (4) selective precipitation of As, Cu, and Co-Ni products, and (5) precipitation of manganese for recycling to the leach circuit. The final process residue is only 1.6 wt-pct of the initial cake and consists of lead sulfate.

RI 8583. Magnetic Properties of Alloys Containing Mischmetal, Cobalt, Copper, Iron, and Magnesium, by J. W. Walkiewicz, J. S. Winston, and M. M. Wong. 1981. 22 pp. 8 figs The Bureau of Mines investigated alloys containing mischmetal (MM), cobalt, copper, magnesium, and iron for use in permanent magnets in place of the scarce samarium-cobalt alloys The magnetic properties of MM-Co, MM-Co-Cu, MM-Co-Cu-Mg, and MM-Co-Cu-Fe-Mg alloys were evaluated. Magnets were fabricated by powder metallurgy consisting of arc-melting the metals, crushing and grinding the resultant alloys, alining and compacting the powder, and sintering the compacts. Magnetic values of $_MH_c$ = 4.7 kOe, $_BH_c$ = 4.07 kOe, B_r = 6.81 kG, and $(BH)_{max}$ = 10.0 MGOe were obtained with a MM-Co alloy containing 36±0.5 wt-pct MM. By substituting copper and magnesium for part of the cobalt, the values for $_MH_c$ and $_BH_c$ were increased to 29.0 kOe and 5.89 kOe, respectively. This intrinsic coercivity value exceeded that of Sm-Co alloy obtained in our laboratory. The addition of iron to MM-Co-Cu-Mg alloys resulted in an increase of B_r to 6.90 kG and $(BH)_{max}$ to 10.3 MGOe. Copper and magnesium contents of these alloys were optimized to obtain maximum values of H_c.

RI 8584. Laboratory Analysis of Pozzolan (Fly Ash) Concrete, by Earl L. Phillips. 1981. 27 pp. 30 figs. The Bureau of Mines conducted laboratory tests on samples of pozzolanic-cement concrete to develop a low-strength backfill. Results show that support costs can be lowered by replacing a portion of the portland cement in mine backfill with pozzolan (fly ash) and lime. Unconfined compression tests on various ratios of fly ash to cement in 84 samples produced compressive-strength curves that can be used to estimate the best backfill mix for any mine.

RI 8585. Monitoring Ground Movements Near Caving Stopes —Methods and Measurements, by Louis A. Panek and Willard J. Tesch. 1981. 108 pp. 63 figs. The Bureau of Mines measured rock-mass movements above the undercutting level in a block-caving mine by means of instrumentation installed in drifts and in long drill holes several hundred feet ahead of the approaching panel caving. The instruments included a borehole inclinometer probe to determine the change of profile along a cased drill hole, break-detection cable monitored by time-domain reflectometry to determine the locations of new cracks, multiple-anchor-position extensometers to measure longitudinal ground movements in boreholes, cross-drift extensometer rosettes to measure the amount and direction of deformation in planes normal to the drift axis, and tiltmeters to determine the change of profile along the drift. Off-the-shelf hardware, components, and instruments were incorporated as much as possible, often in innovative arrangements. To assist the prospective user to devise monitoring schemes for specified measurement objectives and to anticipate the problems that will be encountered, installation and operation of the instruments for this application are described in detail and their comparative advantages are discussed. The sensitivity of measurement was great enough to detect ground movements that preceded cracking, although cracking was found to be pervasive to distances of several hundred feet from the caving boundary.

RI 8586. Monitoring Submicrometer Particles in Sealed Fire Areas, by C. D. Litton, M. Hertzberg, A. L. Furno, and J. M. Kuchta. 1981. 20 pp. 12 figs. Submicrometer particle concentrations and average particle sizes were monitored for four full-scale sealed coal fires in the multiple-entry section of the Bruceton Experimental Mine. The data from these tests indicate that there exists a very good correlation between the submicrometer particle concentrations and the maximum temperatures measured within the coalbed. As the maximum coalbed temperature decreases with time after sealing, the submicrometer particle concentrations show a corresponding reduction. This particle-temperature correlation is in sharp contrast to the gas concentration data obtained, for which essentially no correlation exists with the measured coalbed temperatures. The results of these full-scale tests indicate that the measurement of submicrometer particle concentrations may be a more realistic approach to determining the status of underground sealed fire areas.

RI 8587. Bentonite-Bonded Rammed Olivine and Zircon Molds for Titanium Casting, by R. K. Koch and J. M. Burrus. 1981. 40 pp. 15 figs. The Bureau of Mines produced several series of titanium castings in order to investigate the feasibility of producing commercial-grade titanium castings in bentonite-bonded olivine or zircon sand molds. The use of these molds for titanium casting was investigated as a possible alternative to the industrially used rammed graphite process. Parameters investigated were mold mixtures, mulling, gating, venting, drying, and mold washing. The investigators found that castings with superior ductility and fatigue life, compared with rammed graphite castings, could be made by fume-free processes in molds bonded by western bentonite, using either olivine or zircon sand. Zircon molds were satisfactory for both light- and heavy-sectioned castings. However, olivine molds were suitable only for light-sectioned castings because the mold-metal reaction became excessive during the pouring of heavy-sectioned castings.

RI 8588. Electrochemical Determination of Gibbs Energies of Formation of Cobalt and Nickel Sulfides, by Seth C. Schaefer. 1981. 18 pp. 6 figs. The Bureau of Mines has determined the standard Gibbs energies ($\Delta Gf°$) of $CoS_{1.035}$ (cobalt sulfide) and $Ni_{2.515}S_2$ (nickel sulfide) with high-temperature galvanic cells using stabilized ZrO_2 (zirconia) as the electrolyte.

RI 8589. Recycling of Waste Magnesite-Chrome Refractories From Copper Smelting Furnaces, by A. V. Petty, Jr., and E. Martin. 1981. 18 pp. 7 figs. In accordance with its objective to maximize minerals recovery from secondary domestic resources, the Bureau of Mines conducted research on recycling chrome refractory wastes. Since 20 pct of the U.S. demand for imported chromite is used in the production of refractories, primarily for the steel, copper, and glass industries, samples of used chrome-containing refractories from copper converter and reverberatory furnaces were investigated to determine their potential for recycling. The samples were beneficiated using a combination of wet magnetic separation, flotation, and leaching techniques, and the concentrates were reformed into briquets for refractory evaluation. Small refractory test specimens produced from the beneficiated concentrates gave modulus of rupture values at 1,350° C comparable to those of commercial mag-chrome brick of similar composition; however, grinding the waste refractories to at least minus 65-mesh was required in order to liberate the metallic copper. Most of the copper was easily recovered using conventional beneficiation techniques, but the finely ground chrome concentrate would require briquetting, calcining, and crushing to produce a coarse grain suitable for recycling into secondary mag-chrome refractories. 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 8591. Protection Factors of the Airstream Helmet, by Andrew B. Cecala, Jon C. Volkwein, Edward D. Thimons, and Charles W. Urban. 1981. 17 pp. 8 figs. The Bureau of Mines conducted laboratory and in-mine tests on the Racal airstream helmet (Model #AH21) to evaluate its protection efficiency. Laboratory tests indicated that as ambient air velocity increased, the protection offered by the helmet decreased. In tests conducted at several coal mine longwall sections with face velocities under 400 fpm, the helmet was 84 pet effective at reducing respirable dust in the miner's breathing zone. However, at a high-velocity section, 1,200 fpm, the efficiency of the helmet was significantly reduced, confirming our laboratory results.

RI 8593. Hydrogen Chloride Sparging Crystallization of Aluminum Chloride Hexahydrate, by D. E. Shanks, J. A. Eisele, and D. J. Bauer. 1981. 15 pp. 13 figs. As part of its effort to produce cell-grade alumina from clay, the Bureau of Mines investigated the hydrogen chloride gas-sparging crystallization of aluminum chloride hexahydrate (ACH) from aluminum chloride liquor, to provide information for optimizing the crystallization operation. Four parameters important in controlling the crystallization of the aluminum chloride hexahydrate and the concentration of impurities, particularly phosphorus and magnesium, in ACH crystals are (1) aluminum

chloride concentration in the feed solution to crystallization, (2) hydrogen chloride gas flow rate, (3) temperature, and (4) concentration of phosphorus and magnesium also in the feed solution. Parameters 1, 2, and 3 affect crystal formation. The combined effects are very important because the phosphorus and magnesium concentrate in the crystals during the early stages of crystal growth. Aluminum chloride hexahydrate of cell-grade purity was crystallized from saturated aluminum chloride solutions containing less than 0.003 wt-pct P_2O_5 and 0.010 wt-pct MgO. Crystallization temperatures less than 60° C decreased crystal purity.

RI 8599. Guidelines for Selecting Seismic Detectors for High-Resolution Applications, by C. Melvin Lepper. 1981. 37 pp. 24 figs. To provide the U.S. mining and energy industries with information in the selection of seismic detectors for high-resolution applications, the Bureau of Mines evaluated 35 velocity detectors (geophones) and 9 accelerometers. It was found that velocity detectors with natural frequencies from 10 to 100 Hz were effective for seismic studies in the 5- to 600-Hz spectrum and that accelerometers were most effective in the 100- to 1,000-Hz range. Although the accelerometers described in this report performed about equally with the better velocity detectors tested, the accelerometers showed higher output voltage levels at higher frequencies, which is an advantage. It is important that a seismic detector and its intended purpose be matched properly to achieve the intended results in high-resolution applications. There are many factors that could affect proper matching, thus careful selection of the best detector for a particular application must be exercised.

RI 8600. Electric Ignition of Lycopodium Powder in a Modified Hartmann Apparatus, by T. A. Kubala, F. J. Perzak, and E. L. Litchfield. 1981. 9 pp. 3 figs. Electric discharge ignition has been reinvestigated in a modified Hartmann apparatus for lycopodium powder with air. Minimum stored energy to ignite aid dispersions of lycopodium was 25 to 30 mj; ignition occurred with 1 gram of lycopodium dispersed into the 2.7-liter vessel. Ignition energy was measured as a function of the weight of powder used, although some reservations are expressed concerning the uniformity of the lycopodium-air mixtures. In particular, wall layers of lycopodium, remaining after dispersal of 1 gram of lycopodium, were as easily ignitable as the most easily ignited air dispersion. Thus, an unanswered question has arisen concerning the role of surface coatings in the flammability of all marginally ignitable mixtures.

RI 8602. Electrolytic Method for Recovery of Lead From Scrap Batteries, by E. R. Cole, Jr., A. Y. Lee, and D. L. Paulson. 1981. 19 pp. 4 figs. Bench-scale research at the Bureau of Mines has resulted in the successful development of a combination electrorefining-electrowinning method for recycling all the lead in scrap batteries. The method reduces energy consumption and eliminates toxic emissions, in contrast to present pyrometallurgical smelting, and the lead produced is pure enough for use in maintenance-free batteries. Anodes cast from molten lead scrap were electrorefined in 1- and 2-liter plastic cells using an electrolyte composition of 70 g/l Pb and 90 g/l free H_2SiF_6 (fluosilicic acid). Both reagent-grade and waste H_2SiF_6 were used. Cathode starting sheets were made from refined lead. Aloes, and later bone gelatin, and calcium lignin sulfonate addition agents were employed. The sludge remaining after separation of the lead metal was treated in a two-step leaching operation to solubilize the lead for recovery by electrowinning. Conditions for electrowinning were essentially the same as for electrorefining, except that insoluble PbO_2-Ti (lead dioxide-coated titanium) anodes were used. The best results for electrorefining and electrowinning were obtained with a current density of 170 amp/m^2 and a cell temperature of 25° to 35° C. Cathode purity ranged from about 99.9 to 99.9+ pct Pb. Maximum energy consumption after 3 days, for electrorefining and electrowinning, was 90 and 700 kwhr per metric ton of refined lead, respectively.

MINERAL PERSPECTIVES

The following reports are sales publications and can only be ordered from—

Superintendent of Documents
Government Printing Office
Washington, D.C. 20402

MP. Zimbabwe, by E. Shekarchi, G. Morgan, P. Clarke, and S. Ambrosio. 1981. 62 pp. 9 figs. This Bureau of Mines paper investigates the current status of the mineral industry of Zimbabwe, formerly the British colony of Southern Rhodesia. It also forecasts the expected future position of the country's chromium industry, which is of strategic interest to the United States and the other industrialized countries of the West. In analyzing the capabilities of the mineral industry, the influences of Government policy, current economic conditions, labor supply, energy supply, and transport system are evaluated. Zimbabwe produces over 40 different minerals, the most valuable of which are gold and asbestos. The most important mineral to the West from a strategic point of view is chromite. Zimbabwe has almost one-third of the world's chromite resources but produces less than 10 percent of the total world output. The competitive position of the chromium industry in Zimbabwe has been weakened since the widespread adoption by Western countries of the argon-oxygen-decarburization process for making stainless steel. GPO Stock No. 024–004–02075–0. $4.25.

MP. Mineral Industries of Latin America, by Orlando Martino, Doris Hyde, and Pablo Velasco. 1981. 116 pp. 32 figs. This Bureau of Mines report presents a summary review of the mineral industries of about 34 countries and areas in the Latin American region of the Western Hemisphere. Mineral reserves, production, international mineral trade, and the role of minerals within each country and in terms of world supply are reviewed in text and tables. The principal mining companies are listed, and basic information is presented on labor, energy, and transportation, relative to the mineral industries. Base maps for each country or area show the location of major mines, oilfields and gasfields, and plant facilities—including iron and steel works, nonferrous smelters and refineries, and cement plants. Maps also show major roads, pipelines, railways, and ports that are important to mineral transportation and trade. GPO Stock No. 024–004–02086–5. $5.50.

INFORMATION CIRCULARS

IC 8837. Noise Control of Diesel-Powered Underground Mining Machines, 1979, compiled by J. H. Daniel, J. A. Burks, R. C. Bartholomae, R. Madden, and E. E. Ungar. 1981. 29 pp. 23 figs. This Bureau of Mines report presents results of a survey of underground mining equipment and of two demonstration programs showing the feasibility of quieting a load-haul-dump (LHD) machine and a personnel vehicle. Typical noise levels are presented for the major machine types used in underground mines, along with estimates of the noise overexposure of miners who operate or work near these machines. General principles of noise control are explained, and the application of these principles is illustrated in the description of modifications made to the LHD machine and the personnel vehicle. The noise control package installed on the personnel vehicle lowered its noise level by 14 dbA after 4 months of operation, and inspection of the LHD machine after 2½ years of operation with the modifications showed its noise level 7 dbA lower than that of the unmodified machine. Noise dosimeter measurements indicated that both machines were in compliance with Federal noise regulations for a typical shift.

IC 8838. Polychlorinated Biphenyls: Regulations and Substitutes. A Compliance Manual for the U.S. Mining Industry, by R. A. Westin, R. P. Burruss, B. Woodcock, and R. L. King. 1981. 66 pp. 23 figs. Polychlorinated biphenyls (PCB's) have been widely utilized as fire-resistant dielectric coolants in electrical equipment used in mining applications, including transformers, capacitors, electric motors, and electromagnets. In addition, PCB's have been used in hydraulic fluids and heat-transfer fluids and are present in many oil-filled transformers. The U.S. Environmental Protection Agency (EPA) recently banned the manufacture of PCB's and equipment using PCB's, and imposed strict requirements on the continued use and disposal of existing PCB equipment. This manual discusses the EPA requirements, suggests ways to decrease the risks resulting from continued use of PCB equipment, and surveys the non-PCB equipment that is available as replacements for the PCB electrical equipment presently used in mines.

IC 8839. Minerals Health and Safety Contract Research, Development, and Demonstration in Fiscal Year 1981, by Staff, Division of Minerals Health and Safety Technology. 1981. 36 pp. This publication summarizes, for potential contractors and other interested parties, the research, development, and demonstration contract projects programed by the Bureau of Mines for fiscal year 1981 (October 1, 1980-September 30, 1981) under its Minerals Health and Safety Technology program. Contingencies may require that a significant portion of the program be deferred into fiscal year 1983. The objective of these projects is to provide an ordered and sequenced series of advances toward the Bureau's overall goal of providing the systems technology required to create a healthier and safer working environment for the Nation's mining and minerals processing workers.

IC 8840. Minerals Health and Safety In-House Research, Development, and Demonstration in Fiscal Year 1981, by Staff, Division of Minerals Health and Safety Technology. 1981. 32 pp. This publication summarizes, for all interested parties, the research, development, and demonstration in-house projects programed by the Bureau of Mines for fiscal year 1981 (October 1, 1980-September 30, 1981) under its Minerals Health and Safety Technology program. The objective of these projects is to provide an ordered and sequenced series of advances toward the Bureau's overall goal of providing the system technology required to create a healthier and safer working environment for the Nation's mining and minerals processing workers.

IC 8841. The Noise Exposure of Operators of Mobile Machines in U.S. Surface Coal Mines, 1979, by J. H. Daniel, J. A. Burks, R. C. Bartholomae, R. Madden, and E. E. Ungar. 1981. 24 pp. 10 figs. This report, summarizing the results of two studies sponsored by the Bureau of Mines, presents information on the types of mobile machines used in surface coal mines in the United States, and the amount of noise to which miners are exposed. Data consist of a calculated value of the probability of noise overexposure caused by specific equipment. These data are extrapolated to estimate the number of overexposed operators. Bulldozers were identified as the major contributors to noise overexposure, and the report presents results of a Bureau-funded program on the feasibility of providing retrofit noise control on bulldozers.

IC 8842. Preventing Large-Battery Explosions, by D. Cummins and S. F. Pangerl. 1981. 11 pp. 2 figs. This Information Circular presents a brief history of the lead-acid battery and describes ways to prevent serious injury from battery explosions when servicing and charging lead-acid batteries, particularly in the surface mining industry. The Mining Safety and Health Administration (MSHA), U.S. Consumer Product Safety Commission, battery manufacturers, and the mining industry have all contributed information as well as recommendations for injury-free handling for this report.

IC 8843. High-Temperature Corrosion Resistance of Ceramic Materials, by T. A. Clancy. 1981. 31 pp. Since many new mineral processing systems under development can impose severe corrosive conditions on construction materials, the Bureau of Mines reviewed and assessed the literature on corrosion resistance of ceramic materials. Corrosive conditions were categorized as (1) acids and aqueous solutions, (2) glass and slag/metal melts, and (3) gases. Information on the corrosion resistance of ceramic materials, generally, is disseminated by many sources, each of which is interested in specific corrosive environments. Based on this survey, it was noted that (1) the development of standardized tests is needed to study solution-type corrosion of ceramics, (2) slag/melt corrosion data are the most comprehensive of the available data, and (3) better

definition of corrosion mechanisms in gaseous environments is needed. 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. GPO Stock No. 024–004–02068–7. $2.50.

IC 8844. Minerals Environmental In-House and Contract Research and Development in Fiscal Year 1981, by Staff, Division of Minerals Environmental Technology. 1981. 48 pp. This publication summarizes the in-house and contract research and development projects programmed for fiscal year 1981 by the Bureau of Mines under its Mineral Environmental Technology activity. The document provides a mechanism for interested parties, including potential contractors, to gain insight into ongoing and projected work of the Bureau's environmental research efforts. Research to identify and correct environmental problems associated with mining and metallurgical operations has long been an integral part of the Bureau's mission. The environmental research and demonstration activities of the Bureau were consolidated in 1979 with the formation of the Minerals Environmental Technology program, which is directed toward the elimination or reduction of environmental problems associated with the extraction and processing of minerals. Among the efforts underway are development of data and technology for assessing the potential environmental impact of minerals development, for monitoring minerals extraction operations, and for establishing viable reclamation requirements on abandoned mine lands; development and demonstration of technology for control of environmental disturbances during minerals extraction operations; development and demonstration of land reclamation and mine closure techniques to restore or enhance the productive use of mined lands; development of engineering techniques that incorporate state-of-the-art mining environmental technology in the design and planning of minerals extraction operations; development and demonstration of new mining systems that greatly reduce or eliminate the adverse environmental impacts of minerals extraction; and providing the technologic base for Federal, State, and local establishment of environmental standards for mining operations. Included in the mineral-processing-related work are projects to clean mineral-processing waters; demonstrate a Bureau process for scrubbing SO from powerplant stack gas; recover dissolved minerals from process streams; stabilize discarded dusts, slags, and tailings; remove hazardous contaminates from byproduct wastes; reduce generation of waste solids; and improve metallurgical process engineering to eliminate pollution. Approximately $21 million was appropriated for this work in fiscal year 1981.

IC 8845. State Regulations Pertaining to the Use of Internal Combustion Engines Underground, by Robert W. Waytulonis. 1981. 76 pp. The mining regulations of all 50 States were reviewed by the Bureau of Mines, and those parts pertaining to the use of internal combustion (IC) engines (particularly diesel engines) in underground mines or confined spaces were extracted. Also extracted were subjects associated with the use of IC engines; for example, storage and handling of flammable liquids, maintenance, and ventilation requirements. As the laws now stand, 29 States have specific regulations that affect the operation of diesel engines in underground coal and/or metal and nonmetal mines. The other States have no regulations because either they have no mining activities or they defer to Federal regulations. Six States have regulations expressly prohibiting the use of diesels in underground coal mines. Specific contacts (addresses and phone numbers) precede each State's regulations to facilitate inquiries about regulation revisions and interpretation. GPO Stock No. 024–004–02069–5. $4.25.

IC 8846. Pumped-Slurry Backfilling of Abandoned Coal Mine Workings for Subsidence Control at Rock Springs, Wyo., by G. J. Colaizzi, R. H. Whaite, and D. L. Donner. 1981. 100 pp. 61 figs. The Bureau of Mines, at the request of local authorities in Rock Springs, Wyo., investigated and conducted through contracts a multistage program of exploratory drilling and pumped-slurry backfilling of 15 areas of potential subsidence in abandoned mine workings underneath that community. Initially, the Bureau in 1969 had recommended a program of gravity blind flushing of some of the inaccessible mine voids, and in 1970 a new technique, the pumped-slurry injection process, was tested for the first time in a site adjacent to the city area of severe surface subsidence. Success of this initial testing program, and of a large-scale project in Scranton, Pa., led to further large-scale projects, funded by Congress, that resulted in the successful backfilling not only of all 15 target areas of potential subsidence in Rock Springs, but also of several areas in other States. Total cost of the projects in Rock Springs, including the original pumped-slurry test, was $3,243,993. A total of about 923,000 tons of sand was injected hydraulically into mine voids, rendering 178 acres of residential and central-downtown areas of Rock Springs less susceptible to subsidence damage. The pumped-slurry method was proved to be much superior to the gravity blind flushing method in terms of the amount of solids that could be injected underground through a single borehole. However, there are special conditions that make this technique more or less applicable in different areas or underground configurations, as noted in the report's conclusions. GPO Stock No. 024–004–02065–2. $4.75.

IC 8847. Control of Methane by Ventilation of Shafts During Raise Drilling, by Slavoljub D. Maksimovic. 1981. 11 pp. 8 figs. At some coal mines, methane gas is released during raise drilling. At the request of the Mine Safety and Health Administration (MSHA), U.S. Department of Labor, the Bureau of Mines conducted ventilation surveys at different raise drill sites to assess various methods of reducing methane concentration. The resulting data indicate that raise drill shaft cavities are ventilated by air compressors, vacuum pumps, auxiliary blower fans, and free intake air from the surface. The compressors, pumps, and fans operate simultaneously or separately. At the bottom of the shaft cavities, ventilation is controlled by regulators and airlocks. Methane is monitored, measured, and periodically sampled on the surface, at the bottom and at different levels in the shaft cavities. Maximum concentration of 3.5 percent was measured in one shaft in West Virginia. Air velocity down the raise drill shafts is always very low. Maximum

recorded air down the drill stem was 3,000 cfm, which can be increased by adding air compressors. The best way to ventilate shaft cavities is through the simultaneous use of air compressors and vacuum pumps. If the methane concentration cannot be reduced with additional compressors, then the inside diameter of the drill rod should be increased, or larger pilot hole drill bits should be used.

IC 8848. Cobalt Availability—Domestic. A Minerals Availability System Appraisal, by G. R. Peterson, D. I. Bleiwas, and P. R. Thomas. 1981. 31 pp. 5 figs. The Bureau of Mines evaluated the potential supply of cobalt from known domestic resources, both as a primary product from some deposits and as a byproduct from others, and found that U.S. production could play an important role in meeting U.S. cobalt needs by the mid-1980's. This production would be of a relatively short duration, however, with production declining significantly before the year 2000. As part of the study, a tonnage-price relationship was developed indicating the quantity of cobalt that could be produced from known cobalt-bearing deposits at various primary commodity prices and at a 15-percent rate of return on the required capital investment. All capital and operating costs are calculated in August 1980 dollars, and commodity prices are based on August 1980 prices. Known U.S. cobalt-bearing deposits which represent the current U.S. cobalt reserve base contain about 310,800 metric tons of cobalt in slightly over 1 billion metric tons of demonstrated mineralized material. Approximately 37 percent of the cobalt contained in the reserve base is considered recoverable using existing technology. Of this quantity, about 87,000 metric tons of cobalt is economically recoverable assuming a cobalt price of $25 per pound, a copper price of $1 per pound, and a lead price of $0.40 per pound. Assuming that the cobalt price decreases to $15 per pound, keeping copper and lead prices constant, the quantity that is considered economically recoverable declines to about 45,700 metric tons. Domestic cobalt consumption in 1979 was 7,900 metric tons (17.4 million pounds). Currently, no primary cobalt is produced from domestic resources, and none has been produced since 1971. GPO Stock No. 024–004–02077–6. $2.75.

IC 8849. Room and Pillar Retreat Mining. A Manual for the Coal Industry, by Peter W. Kauffman, Steven A. Hawkins, and Robert R. Thompson. 1981. 228 pp. 107 figs. This Bureau of Mines publication is designed primarily to provide mine engineers and production-level mine managers with the following: (1) Information to assist them in making the decision to retreat mine and in selecting the best retreat mining technique for specific mining conditions. (2) Information on mine planning that will enable them to design mine layouts for safe and efficient retreat mining. (3) Information that will enable them to develop a section foreman's handbook. The manual has been organized to gradually increase in level of detail as the reader progresses from beginning to end. Individuals interested in an overview of retreat mining can confine themselves to the first few chapters. Those interested in mine planning should read the middle chapters as well. Those interested in the development of a foreman's handbook should read the entire manual. GPO Stock No. 024–004–02071–7. $6.50.

IC 8850. Economic Significance of the Florida Phosphate Industry. An Input-Output (I-O) Analysis, by Anthony M. Opyrchal and Kung-Lee Wang. 1981. 62 pp. 17 figs. This Bureau of Mines study assesses the economic significance of the Florida phosphate industry to selected counties in Florida, the State of Florida, and the Nation; it also includes a brief survey of the industry's international impact. Based on forecasts of Florida phosphate production in 1981, and using constant 1977 dollars, estimates are given for 1981 for regional and national output, the value of this output, income, and employment created by the phosphate industry in Florida. Federal, State, and county tax revenues generated by the State's phosphate industry are also estimated for 1981. The concentrated impact of the phosphate industry on certain areas of Florida and on the State's regional industries is examined using economic base analysis complimented by an industrial complex approach. The industry's impact at the State and national levels is examined through input-output analysis. In addition, an attempt to forecast for 1990 the effects of constraints on phosphate rock mining as a result of economic conditions and other factors is included as an appendix to the report. Also discussed is the phosphate industry's importance to the U.S. balance of trade; U.S. agricultural production, including forward linkages; the U.S. sulfur industry; and the phosphate industry's importance to the production of fluorine and uranium byproducts from fertilizer manufacturing. GPO Stock No. 024–004–02074–1. $4.25.

IC 8851. Selection of Lixiviants for In Situ Uranium Leaching, by Daryl R. Tweeton and Kent A. Peterson. 1981. 35 pp. This Bureau of Mines publication provides information to assist in selecting a lixiviant (leach solution) for in situ uranium leaching. The cost, advantages, and disadvantages of lixiviants currently used and proposed are presented. Laboratory and field tests are described, and applications of geochemical models are discussed. Environmental, economic, and technical factors should all be considered. Satisfying environmental regulations on restoring groundwater quality is becoming an overriding factor, favoring sodium bicarbonate or dissolved carbon dioxide over ammonium carbonate. The cheapest lixiviant is dissolved carbon dioxide, but it is not effective in all deposits. Technical factors include clay swelling by sodium, acid consumption by calcite, and the low solubility of oxygen in shallow deposits. Laboratory leaching tests can provide useful data. However, they can be misleading if, for example, the ore is allowed to oxidize before testing or if distilled water instead of formation water is used for making solutions for permeability tests. Geochemical models presently are more useful for indicating trends in solubility than in reliably predicting concentrations. GPO Stock No. 024–004–02078–4. $2.75.

IC 8852. In Situ Mining Research. Proceedings: Bureau of Mines Technology Transfer Seminar, Denver, Colo., August 5, 1981, compiled by Staff—Bureau of Mines. 1981. 107 pp. 37 figs. These proceedings consist of an overview of the in situ mining research currently being carried out by the Bureau of Mines. The following papers emphasize two general aspects of the in situ mining method: the environment and productivity. Both areas are extremely important, particularly because in situ leach mining is a relatively new mining method from a commercial point of view. Topics covered include the restoration of ground water, the selection of lixiviants, in situ mining of commodities other than uranium, in situ mining costs, the application of resistance measure-

ments to in situ mining, an acid leach mining case history, and the use of branched boreholes for in situ mining. A bibliography of Bureau of Mines publications on in situ mining is appended.

IC 8853. Proceedings of the Workshop on Techniques for Measurement of Thermodynamic Properties, Albany, Oreg., August 21–23, 1979, compiled by N. A. Gokcen, R. V. Mrazek, and L. B. Pankratz. 1981. 438 pp. 101 figs. To improve communication among Government, industry, and academic researchers in the field of thermodynamics, the Federal Bureau of Mines sponsored a Workshop on Techniques for Measurement of Thermodynamic Properties in August 1979. Participants at the workshop presented 33 papers on the subjects of temperature measurement and control, general calorimetric techniques, low-temperature calorimetry, high-temperature calorimetry, galvanic cells, ionic solutions, and heterogeneous phase equilibria. A special invited lecture was presented by E. F. Westrum, Jr., on the resolution of lattice heat capacity. This Information Circular comprises the proceedings of the workshop and includes the texts of papers presented and discussion by attendees.

IC 8854. Minerals and the Tokyo Round of the MTN, by Daniel E. Sullivan. 1981. 18 pp. This Bureau of Mines publication examines the potential impact on minerals of the tariff and nontariff agreements that resulted from the Tokyo Round of the Multilateral Trade Negotiations, which were conducted under the auspices of the General Agreement on Tariffs and Trade. These agreements will affect minerals by reducing tariff levels and by changing rules by which they are traded internationally. GPO Stock No. 024–004–02076–8. $2.75.

IC 8855. Uranium Mine Ventilation Costs, by Robert C. Bates. 1981. 18 pp. 4 figs. This Bureau of Mines report converts published data on the cost of ventilating uranium mines to a common price base and analyzes these data to determine the cost per ton of uranium ore at various levels of radiation exposure control. There appears to be an exponential increase of cost as the radiation level is lowered. The 1967 base costs are extrapolated to present dollars, and some cost comparisons are given for other radiation control measures. GPO Stock No. 024–004–02084–9. $2.25.

IC 8856. Analyses of Natural Gases, 1980, by B. J. Moore. 1981. 236 pp. 1 fig. This publication contains analyses and related source data for 675 natural gas samples from wells and pipelines in 24 States and 5 foreign countries. The samples obtained and analyzed during calendar year 1980 are included in tables 1–4. Those samples included in tables 5–7 were collected during the years 1960 through 1979. However, permission to publish the analyses of those samples was not given until the past year when the operators were again contacted to seek release of the information. All of these samples were collected as a 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 in the United States by the Bureau of Mines since 1917. In late 1965, the survey was expanded to include foreign gasfields. The analyses published herein were made by mass spectrometer and a special helium analysis apparatus, which are described in Bureau of Mines Bulletins 486 and 576. GPO Stock No. 024–004–02085–7. $7.

IC 8857. Mine Waste Disposal Technology. Proceedings: Bureau of Mines Technology Transfer Workshop, Denver, Colo., July 16, 1981, compiled by Staff—Minerals Research. 1981. 70 pp. 53 figs. This Bureau of Mines publication consists of an overview of the mine waste management research currently being conducted by the Bureau. The following papers, given at a Technology Transfer Workshop, emphasize the increasing importance of research related to the safety and environmental considerations of mine waste disposal in recent years. Current work related to legislation passed in the last 10 years and their subsequent standards includes the development of adequate monitoring systems, development of stability and seepage prediction and control techniques, control of runoff water, and control of leaching solutions. Selected topics are included here that cover coal mine waste disposal, embankment slope stability monitoring, flow failures of mine tailings impoundments, and controlled burnout of abandoned coal mine fires. The projects described provide a current documentation of problems being addressed.

IC 8858. Mine Safety Education and Training Seminar. Proceedings: Bureau of Mines Technology Transfer Seminars, Pittsburgh, Pa., Dec. 9, 1980, Springfield, Ill., Dec. 12, 1980, and Reno, Nev., Dec. 16, 1980, compiled by Staff—Pittsburgh Research Center. 1981. 76 pp. 16 figs. Research personnel from the Bureau of Mines, a representative of the Mine Safety and Health Administration, and research contractors for the Bureau of Mines met with other Government and industry representatives at three seminar locations in December 1980 to discuss the findings and products of Bureau research on mine safety training. The research program is aimed at providing assistance to the mining community in its efforts to reduce industrial-type, human-error accidents through research establishing performance based methods and media for employee training. Research emphasis is directed toward development of baseline materials and instructional models; development of methods for structuring and evaluating health and safety, supervisory, and occupational training; and the continued investigation and application of current learning and simulation technology that could significantly enhance the effectiveness of training opportunities.

IC 8859. An Introduction to the Mine Inspection Data Analysis System (MIDAS), by W. F. Watts, Jr., R. L. Johnson, D. J. Donaven, and D. R. Parker. 1981. 41 pp. 11 figs. This report describes the Mine Inspection Data Analysis System (MIDAS) developed by the Bureau of Mines to analyze the records of industrial hygiene samples collected by the Mine Safety and Health Administration (MSHA) in metal and nonmetal mines. MIDAS is the first system capable of sorting, editing, analyzing, and reporting these data. It is also the first system designed to be used by a number of Government agencies. At present the system contains 225,000 personal and area samples for 61 contaminants in 45 industries. The records date from 1974 to early 1980, and MSHA plans to provide yearly updates to the system. This report presents preliminary analyses of dust exposures and discusses the potential uses and limitations of these data. Analysis of the dust data for 1978 and 1979 showed that bagging had the highest percentage of dust overexposure. More than 40 pct of the 1,536 respirable quartz dust, total nuisance dust, and total silica dust samples exceeded the MSHA exposure limit. Other

dusty occupations are ranked according to their percentage of overexposure.

IC 8860. Operation of the International Tin Agreement, by Thomas J. Witzig. 1981. 24 pp. 5 figs. This Bureau of Mines report is a background study of the International Tin Agreement. Attempts at stabilizing the tin market prior to the agreement are detailed, as well as the conditions and negotiations that set up the agreement. Details of the five consecutive 5-year agreements beginning in 1956 are presented, with emphasis on membership and the agreements' primary tools: the buffer stock and export controls. Attention is focused throughout on the United States activities during the period, especially with regard to its strategic stockpile, and its involvement with the agreement culminating in its membership, for the first time, in the fifth agreement beginning in 1976. Considerations leading to the U.S. decision to join are detailed, and U.S. activities in the negotiations for the sixth agreement are presented. The status and outlook for the agreement are discussed, and evaluations of the effectiveness of the agreement and its components are reviewed. GPO Stock No. 024–004–02081–4. $2.50.

IC 8861. Alumina Availability—Domestic. A Minerals Availability System Appraisal, by Gary R. Peterson, Robert L. Davidoff, Donald I. Bleiwas, and Richard J. Fantel. 1981. 23 pp. 8 figs. In order to determine the potential availability of alumina to feed U.S. aluminum smelters, the Bureau of Mines evaluated 39 domestic mines and deposits of bauxite, alunite, and high-alumina clays and found that substantial increases in alumina prices would be necessary before nonbauxite deposits could become competitive with bauxite. As part of the study, a price-tonnage relationship was developed indicating the quantity of alumina that could be produced from known deposits at various alumina prices and at a 15-pct discounted cash flow rate of return on the required capital investment. All capital and operating costs were calculated in August 1980 dollars. The domestic bauxite reserve base comprises three operating bauxite mines in Arkansas containing about 15.6 million metric tons of recoverable alumina (Al_2O_3). Ferruginous bauxites, clays, and alunites fall into the subeconomic category of identified aluminum resources, which, at the demonstrated level, contain over 4,000 million metric tons of alumina that are estimated to be recoverable. Analyses indicate that, at the demonstrated resource level, a total of about 15.6 million metric tons of alumina, all from three active Arkansas bauxite mines, is recoverable at a 1980 price of $0.12 per pound ($264 per metric ton) of alumina. A price of approximately $0.26 per pound ($573 per metric ton) of alumina would be required for production of the total U.S. resource. Thus, unless new technological breakthroughs occur that could make alternate sources of alumina competitive with bauxite, U.S. dependence upon imported bauxite will continue to increase. GPO Stock No. 024–004–02080–6. $2.50.

IC 8865. Underground Metal and Nonmetal Mine Fire Protection. Proceedings: Bureau of Mines Technology Transfer Seminars, Denver, Colo., Nov. 3, 1981, and St. Louis, Mo., Nov. 6, 1981, by Staff, Bureau of Mines. 1981. 150 pp. 93 figs. These proceedings consist of an overview of the underground metal and nonmetal mine fire protection research currently being conducted by the Bureau of Mines. The following papers address the areas of prompt, reliable fire detection, fire planning and warning, fire suppression, and personnel protection. Selected topics are included here that cover fire protection systems for shafts, underground fueling areas, and mobile underground mining equipment; spontaneous combustion, improved stench, and product-of-combustion fire warning systems; computer-aided ventilation modeling; fire doors; and an investigation of fire hazards in mine timbers. The projects described provide a current documentation of problems being addressed.

IC 8866. Ergonomics-Human Factors in Mining. Proceedings: Bureau of Mines Technology Transfer Seminars, Pittsburgh, Pa., December 3, 1981, St. Louis, Mo., December 10, 1981, and Denver, Colo., December 15, 1981, compiled by Staff, Pittsburgh Research Center. 1981. 167 pp. 17 figs. These proceedings consist of papers presented at three Bureau of Mines Technology Transfer Seminars on ergonomics in the mining industry. These seminars were held in December 1981, and covered topics relating to ergonomics and mining in the areas of the man-machine interface, and design of the work environment. This area of research is directed toward reducing accidents traditionally associated with human error.

IC 8867. Borehole Shear Tester: Equipment and Technique, by Khamis Y. Haramy. 1981. 19 pp. 21 figs. This Bureau of Mines paper describes the use of the borehole shear tester (BST) in mines. Assembly and procedure sections explain how the equipment is assembled and used properly. Schematics of the BST, limitations, test hole specifications, data recording, and calculations are all explained briefly, and an example of the data collecting and calculations is given to assist understanding.

IC 8869. Critical and Strategic Minerals in Alaska: Cobalt, the Platinum-Group Metals, and Chromite, by James C. Barker, Jan C. Still, Thomas C. Mowatt, and John J. Mulligan. 1981. 8 pp. 3 figs. A uniquely mineralized area extends from northwestern Canada through Alaska into eastern Siberia. Some of the metals found there are relatively rare in the conterminous United States. Among these are cobalt, the platinum-group metals, and chromite. Geologic evidence suggests that cobalt and the platinum-group metals may be present in deposits that could constitute nationally important reserves. Chromite in potentially minable deposits is known, but it may be relatively less abundant. Limited reserves of these metals have been delineated, but most of the favorable terranes and reported occurrences throughout the vast expanse of Alaska remain unexplored. As part of the mineral studies mandated under the Alaska National Interest Lands Conservation Act, the Bureau of Mines' Alaska Field Operations Center and the Bureau's research centers at Albany, Oreg., and Reno, Nev., are cooperating in a long-range program to investigate occurrences and delineate reserves of cobalt, the platinum-group metals, and chromite in Alaska. Studies of other critical and strategic minerals will be phased in during succeeding years, as ongoing projects are completed. This first in a series of annual reports summarizes available information about deposits and past production of cobalt, the platinum-group metals, and chromite, and describes current and planned Bureau investigations of these minerals. GPO Stock No. 024–004–02088–1. $2.

SPECIAL PUBLICATIONS

SP 1–81. Bureau of Mines Research 80. A Summary of Significant Results in Mineral Technology and Economics, compiled and edited by Janice D. Burket. 1980. 127 pp. 65 figs. The Bureau of Mines is responsible for a broad spectrum of programs for meeting the diverse and changing mineral resource needs of the Nation. Bureau program activities are classified into two major functions: (1) Developing new and improved technology that will make the production and processing of minerals more efficient, safer and more healthful for mineral workers and the public, and more compatible with a quality environment. (2) Acquiring statistical and economic knowledge related to mineral materials, their availability, production, and use, and performing mineral problem and policy analysis. Research 80, the 10th in an annual publication series, reflects the scope of the Bureau's mission and the success with which that mission is being pursued. GPO Stock No. 024–004–02022–9. $4.75.

SP 2–81. Federal Land Status in the Overthrust Belt of Idaho, Montana, Utah, and Wyoming, 1979, by Otto L. Schumacher, Andrew W. Berg, Fred V. Carrillo, Ronald A. Pense, and Robert B. Davis. 1980. 22 pp. 6 figs. The Overthrust Belt in portions of Montana, Idaho, Utah, and Wyoming, an area that has contributed generously to the Nation's mineral supply, is one of the few remaining oil and gas frontiers on the North American Continent. Determination of the oil and gas potential and development of mineral resources of the area have been affected by a variety of land withdrawals and other restrictions. The purpose of this study is to determine the extent of these wihdrawals and restricions and to discuss the mineral resource potential within the study area. Satistics in this report refer to land status on January 1, 1979. At that time, of the 27.3 million acres of Federal mineral lands within the study area, applications for Federal oil and gas leases for more than 4.4 million acres (about 16 percent) were pending; the average length of time was 2 years. Federal oil and gas leases covering 8.8 million acres were also on record. Although drilling has occurred on some of these leases, others are subject to restrictions that discourage or prevent development. Some in fact contain stipulaions disallowing any development. As of January 1, 1979, special restrictions ranging from complete prohibition of mineral development to restrictions having slight effect on mineral development, were in effect for 18.2 million acres (67 percent of the Federal mineral estate, or 39 percent of the entire study area). Since the survey of land status was completed, release of RARE II and Bureau of Land Management (BLM) roadless areas determined to be unsuitable for Wilderness has reduced this acreage by 5.9 million acres and has reduced the total acreage restricted for Wilderness reasons by 8.9 million acres. However, part of this released acreage is now covered by other restrictions imposed by management policy. Restricted lands include wilderness areas, proposed wilderness areas, RARE II lands, BLM roadless areas, and national parks. Also included are restrictions imposed by management policy for protection of key wildlife habitat, recreation or scenic values, watershed, and research uses. Mineral leasing outside these areas can also be affected by incomplete land-use plans, legal restraints, and uncertainty concerning habitat for endangered and threatened wildlife. The report contains 14 over-size maps. GPO Stock No. 024–004–02003–2. $12.

SP 3–81. Mineral Dependency Versus Mineral Vulnerability, by Lindsay D. Norman. Pres. at 83d Nat. Western Min. Conf., Denver, Colo., February 1980. 8 pp. America's increasing mineral dependency on foreign sources of supply has become a major issue. In many cases, however, the trend toward increased imports that many characterize as "dependency" is a natural outcome of post-World War II international prosperity, and of America's vigorous participation in world trade. We should distinguish between mere dependency and true vulnerability, a distinction that may not always be easy to make without a careful analysis of the situation for a given mineral. The Bureau of Mines is expanding its capacity to make such analyses, as the basis for policy formulation, and to conduct research toward technologies that can increase our mineral self-sufficiency as necessary. GPO Stock No. 024–004–02004–1. $1.25 single copy; $14 per 100 copies.

SP 4–81. Capital and Operating Cost Estimating System Manual for Mining and Beneficiation of Metallic and Nonmetallic Minerals Except Fossil Fuels in the United States and Canada, by George K. Clement, Jr., Robert L. Miller, Philip A. Seibert, Louis Avery, and Harold Bennett. 1981. 149 pp. 129 figs. The Bureau of Mines is establishing a computerized mineral inventory system to help the Federal Government appraise its mineral position and prepare programs insuring against critical shortages of materials. This system, called the Minerals Availability System (MAS), is a component of the Bureau's minerals intelligence function designed to conduct and maintain an inventory of minerals important to the Nation. The MAS defines the physical and commercial availability of the mineral resources. Known resources are evaluated and classified by deposit for entry into a computer storage and retrieval system. An integral concern of these evaluations is the cost of obtaining and beneficiating the ore contained in specific deposits. To meet this concern, a cost handbook was developed as an aid to preparing feasibility-type estimates for capital and operating costs of mining and primary beneficiation of various types of mineral occurrences. Cost data, obtained from U.S. and Canadian companies, were used as the basis of this handbook. The handbook presents cost curves and equations for each component of the mining and beneficiation process. Factors for each cost component are also given, thereby allowing the updating of cost for time, geographic location, labor rates, and mining and milling conditions. Included in the latter conditions are items such as the length of haul, need for rock bolts, and a rock work index for ores and rocks of various hardnesses. GPO Stock No. 024–004–02015–6. $5.50.

SP 5–81. Creating a Safer Environment in U.S. Coal Mines. The Bureau of Mines Methane Control Program, 1964–79, by Milford L. Skow, Ann G. Kim, and Maurice Duel. 1980. 50 pp. 45 figs. This report summarizes the principal activities and results of 15 years of research by the Bureau of Mines, U.S. Department of the Interior, on methane control in coal mines. This research has investigated fundamental factors regarding the occurrence and movement of methane in coalbeds, removal of methane prior to mining, and control of methane during mining. The report includes a bibliography listing the more than 150 publications resulting from the Bureau's methane control program as well as numerous other references, a section on methane recovery and use, a look at the upcoming Bureau of Mines research program, and a brief review of methane drainage practices in other coal-producing countries. GPO Stock No. 024–004–01969–7. $3.50

SP 6–81. List of Bureau of Mines Publications and Articles, January 1, 1975, to December 31, 1979. With Subject and Author Index, compiled by Shelby Z. Palya. 1981. 568 pp. This publication lists and summarizes publications by Bureau authors published in the regular Bureau of Mines series, in scientific, technical, or trade journals, or in other media; those available from the Bureau of Mines are indicated. Patents issued to Bureau personnel are also listed, and instructions are given on how to apply for permission to use them. One of the outstanding features of this Special Publication is an exhaustive subject and author index. GPO Stock No. 024–004–02079–2. $12.

SP 7–81. Technical Highlights: Health and Safety Research, 1970–80, by Staff, Bureau of Mines. 1981. 181 pp. 236 figs. Under provisions of the Federal Coal Mine Health and Safety Act of 1969, and the Amendments Act of 1977, the Bureau of Mines is conducting research to improve the health and safety of workers in the minerals industries. This document presents an overview of selected accomplishments implemented through the Bureau's Minerals Health and Safety Program.

SP 8–81. Bureau of Mines Research 81. A Summary of Significant Results in Mineral Technology and Economics, compiled by Jerald R. Pederson. 1981. 148 pp. 118 figs. The Bureau of Mines is responsible for a broad spectrum of programs for meeting the diverse and changing mineral resource needs of the Nation. Bureau program activities are classified into two major functions: (1) Developing new and improved technology that will make the production and processing of minerals more efficient, safer and more healthful for mineral workers and the public, and more compatible with a quality environment. (2) Acquiring statistical and economic knowledge related to mineral materials, their availability, production, and use, and performing mineral problem and policy analysis. Research 81, the 11th annual summary of significant results in mineral technology and economics, reflects the scope of the Bureau's mission, and the success with which that mission is being pursued. GPO Stock No. 024–004–02082–2. $6.

COOPERATIVE PUBLICATIONS

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

FBG 1–81. The Hawthorn Formation of Central Florida. Part I—Geology of the Hawthorne Formation in Central Florida, by Thomas M. Scott and Peter L. MacGill. **Part II—Characterization, Evaluation, and Beneficiation of Central Florida Phosphate-Bearing Hawthorn Formation,** by W. H. Eddy, B. E. Davis, and G. V. Sullivan. Fla. Bureau of Geol. RI 91. 1981. 107 pp. 10 figs.

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.

GS 1–81. Mineral Resources of the Scotchman Peak Wilderness Study Area, Lincoln and Sanders Counties, Montana, and Bonner County, Idaho, by the U.S. Geological Survey and U.S. Bureau of Mines. With sections on geology, by Robert L. Earhart; aeromagnetic and gravity studies, by M. Dean Kleinkopf and Dolores M. Wilson; geological and geochemical evaluation of the mineral resources, by David J. Grimes and Robert L. Earhart; and economic appraisal, by Nicholas T. Zilka. 1981. 73 pp. 17 figs. 2 pl. Geol. Survey Bull. 1467. GPO Stock No. 024–001–03379–8. $4.75.

GS 2–81. Mineral Resources of the Galiuro Wilderness and Contiguous Further Planning Areas, Arizona, by S. C. Creasey, J. E. Jinks, F. E. Williams, and H. C. Meeves. With a section on aeromagnetic survey and interpretation, by W. E. Davis. 1981. 94 pp. 16 figs. 2 pl. Geol. Survey Bull. 1490. GPO Stock No. 024–001–03438–7. $4.75.

GS 3–81. Mineral Resources of the Lone Peak Wilderness Study Area, Utah and Salt Lake Counties, Utah, by Calvin S. Bromfield and Lowell L. Patten. With a section on interpretation of aeromagnetic data, by Don R. Mabey. 1981. 117 pp. 40 figs. 2 pl. Geol. Survey Bull. 1491. GPO Stock No. 024–001–03423–9. $7.

GS 4–81. Mineral Resources of the Cranberry Wilderness Study Area, Webster and Pocahontas Counties, West Virginia, by Charles R. Meissner, Jr., John F. Windolph, Jr., Peter C. Mory, and Donald K. Harrison. With sections on peat resources, by Cornelia C. Cameron and Andrew E. Grosz; oil and gas potential, by William J. Perry, Jr.; and geochemical survey, by Frank G. Lesure. 1981. 61 pp. 19 figs. 3 pl. Geol. Survey Bull. 1494. GPO Stock No. 024–001–03389–5. $4.25.

GS 5–81. Mineral Resources of the Snow Mountain Wilderness Study Area, California, by Robert D. Brown, Jr., David J. Grimes, Reinhard Leinz, Francis E. Federspiel, and Andrew M. Leszcykowsky. With a section on interpretation of aeromagnetic data, by Andrew Griscom and Robert D. Brown, Jr. 1981. 48 pp. 7 figs. 2 pl. Geol. Survey Bull. 1495. GPO Stock No. 024–001–03440–9. $5.50.

GS 6–81. Mineral Resources of the Strawberry Mountain Wilderness and Adjacent Areas, Grant County, Oregon, by Thomas P. Thayer, James E. Case, and Ronald B. Stotelmeyer. 1981. 67 pp. 13 figs. 2 pl. Geol. Survey Bull. 1498. GPO Stock No. 024–001–03445–0. $5.50.

GS 7–81. Mineral Resources of the Rincon Wilderness Study Area, Pima County, Arizona, by Charles H. Thorman, Harold Drewes, and Michael E. Lane. 1981. 62 pp. 1 fig. 2 pl. Geol. Survey Bull. 1500. GPO Stock No. 024–001–03454–9. $6.

GS 8–81. Mineral Resources of the Cabinet Mountains Wilderness, Lincoln and Sanders Counties, Montana, by the U.S. Geological Survey and U.S. Bureau of Mines. 1981. 77 pp. 19 figs. 2 pl. Geol. Survey Bull. 1501. GPO Stock No. 024–001–03393–3. $4.50.

GS 9–81. Mineral Resources of the Rainbow Lake Wilderness Area and the Flynn Lake Wilderness Study Area, Bayfield County, Wisconsin, by W. F. Cannon, Cornelia C. Cameron, Andrew E. Grosz, Maynard L. Dunn, Jr., Gertrude C. Gazdik, and James J. Hill. 1981. 19 pp. 8 figs. 1 pl. Geol. Survey Bull. 1511. GPO Stock No. 024–001–03455–7. $3.75.

GS 10–81. Mineral-Resource Evaluation of the Round Lake Wilderness Study Area, Price and Vilas Counties, Wisconsin, by William F. Cannon, Cornelia C. Cameron, John S. Klasner, Andrew E. Grosz, and Bradford B. Williams. 1981. 23 pp. 9 figs. 1 pl. Geol. Survey Bull. 1512. GPO Stock No. 024–001–03416–6. $4.

TECHNICAL PROGRESS REPORTS

The following publications can be obtained from—

Section of Publications
Bureau of Mines
U.S. Department of the Interior
4800 Forbes Avenue
Pittsburgh, Pa. 15213

TPR 111. Reducing Dust at Longwall Shearers by Confining the Dust Cloud to the Face, by Fred Kissell, Natesa Jayaraman, Charles Taylor, and Robert Jankowski. 1981. 21 pp. 15 figs. The Bureau of Mines has developed the shearer-clearer—a new type of dust control system for longwall shearers. The system partitions the airflow around the shearer into a clean split and a contaminated split. The dust cloud is confined to the vicinity of the coal face, while the shearer operators remain in the clean split on the gob side of the machine. The shearer-clearer operates on the principle that each water spray moves air like a small fan and can be positioned to direct the duty air towards the face. The hardware is inexpensive and can be installed in a single shift. It consists of several strategically mounted water sprays and one or more passive barriers. Laboratory testing indicates reductions in shearer operator dust exposure as high as 97 pct. Preliminary results from an underground demonstration in one mine also indicate that considerable dust reductions at the shearer may be obtained. In conjunction with the development of the shearer-clearer, dust surveys were conducted in three other mines to determine if some shearer spray systems currently in use partition the flow in a manner similar to the shearer-clearer, and if so, whether this partially accounts for markedly cleaner conditions on some longwalls. Results from these surveys indicate this to be the case. A feature of the cleaner longwalls was a downwind orientation of their water sprays, which is a key element of the shearer-clearer system. The shearer-clearer system described in this report was designed for an Eickhoff EDW 300 shearer working a 7-foot coal seam. The testing to date has concentrated on cutting directions counter to the primary airflow. The development effort continues for different mining equipment and conditions. It is expected that different systems will be required to accommodate the range of conditions occurring underground. Application of the system presented here to conditions different than those described is not likely to produce the same results.

TPR 112. New Twin Scrubber Installation for Continuous Mining Machines, by Edward F. Divers, John C. LaScola, and Gerald J. Hundman. 1981. 10 pp. 4 figs. This Bureau of Mines report describes a new type of scrubber (dust collector) and ventilation system built into the auger support frame (boom) of a Jeffrey 120L continuous mining machine. With this twin scrubber arrangement, one scrubber is mounted into each side of the boom. Each scrubber includes a 2,500-cfm fan, a flooded fibrous-bed scrubber panel, and a water droplet eliminator. The system was designed for minimum size and adds only a few inches to machine height. Exhaust duct design allows flexibility with various airflow configurations to suit both blowing and exhaust face ventilation systems and brattice distances ranging up to 20 feet. Full-scale tests with exhaust ventilation were conducted at a Mine Safety and Health Administration surface facility at Bruceton, Pa., to determine the scrubbers' methane dilution capability. Several configurations of the twin scrubber-ventilation system produced striking improvements in face methane dilution when compared with conventional systems.

TPR 113. Convergence Measurements for Squeeze Monitoring: Instrumentation and Results, by Eric R. Bauer and Gregory J. Chekan. 1981. 9 pp. 9 figs. The magnitude and rate of advance of an in-mine coal squeeze was determined by measuring roof-to-floor convergence on a regular basis. A dial-gage tube extensometer was used to collect data. Using these measurements, Bureau of Mines employees drew contour maps and graphs to show the direction and rate of squeezing. Information on the rate of squeeze advance was used to determine whether steps should be taken to prevent roof and/or floor movement from closing an entire section of the mine and if alteration of mining plans was necessary to prevent further squeeze development. Data analysis revealed that the squeeze was decelerating; thus there was no need to strengthen support in the areas of the mine that were studied. Mining plans were altered, however, as a result of the findings of this investigation.

TPR 114. The Water Spray Cooler — An Update, by Edward D. Thimons and J. Harrison Daniel. 1981. 9 pp. 4 figs. The water spray cooler is a direct-contact air-to-water heat exchanger designed to cool the hot working areas of deep mines. This cooler was originally developed by the Bureau of Mines. Recent tests with water spray coolers at the Homestake gold mine in South Dakota proved their thermal performance to be superior to that of the conventional finned-coil coolers in use at the mine. Testing has also shown that water spray coolers require little maintenance, whereas finned-coil coolers need maintenance for dust removal every 2 weeks.

OPEN FILE REPORTS

OFR 1–81. Improved Ore Recovery From Phosphate Open-Pits in the Phosphoria Formation, by W. A. Young, G. M. Pugh, G. D. Vandersluis, and V. Lim. March 1980. 314 pp. 50 figs. To initiate this project, a critical evaluation of the present phosphate mining industry in the Western phosphate field was conducted. Mines were visited, mine operators were interviewed, and pertinent literature studied. Three phosphate mining enterprises were reviewed and mining cost estimates prepared. The report discusses the present state of phosphate processing, rock alteration, and location. New ideas and concepts are proposed to improve the recovery of phosphate rock from the Phosphoria Formation. The report evaluates two variations to the present phosphate open pit mining methods, which were developed to improve the economics of mining phosphate and to better accomplish necessary reclamation and accelerate the time for environmental recovery. A materials handling system using conveyor haulage will eliminate the need for trucks. Terrace haulback utilizes safety benches to haul and dispose of waste in the mined-out pit. Ore will be removed from the pit by an inclined, cable-supported mobile conveyor. Research done under Contract No. J0285017 by Dravo Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–167512; paper copy price code A14.

OFR 2(1)–81. Wire Rope Terminations. Volume I. Efficiency and Service Life of Wire Rope Terminations, by F. Matanzo. Aug. 10, 1978. 152 pp. 39 figs. Nine wire rope terminations were pull and fatigue tested to destruction to measure the termination efficiency and relative fatigue life. The terminations were selected on the basis of mine site visits and the specimens were assembled in a manner similar to industrial slings. To measure a termination's sensitivity to poor manufacturing, both standard and modified assembly specimens were tested. In static pull tests rope class, construction, and diameter interacted with the termination to influence the efficiency of the termination. In axial fatigue tests the effect of rope construction was negligible since failure was primarily dependent on the termination type. The swaged socket, a termination requiring a high-capacity hydraulic press, gave the best overall performance in terms of efficiency and fatigue life; the short body length of the zinc-poured socket was attributed with the short fatigue life. The use of thermosetting resins as a replacement for zinc was demonstrated successfully for some socket designs. The fatigue life of the termination, expressed as a percentage of the fatigue life of the wire rope, was shown to be a guide for the retirement of the wire rope where those applications are primarily in axial loading. Research done under contract H0166079 by Engineering Services Co. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md. Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–168825; paper copy price code A08.

OFR 2(2)–81. Wire Rope Terminations. Volume II. Selection and Inspection Guide for Wire Rope Terminations, by F. Matanzo. Aug. 10, 1978. 30 pp. 26 figs. This guide considers nine of the many wire rope terminations used in the mining industry, thus use of the information presented for terminations not specifically addressed can be done, but with some risk. The guide uses pull test data, axial fatique test data, and data on sensitivity to poor manufacturing to rank the terminations with respect to these performance measures. A selection procedure is suggested and illustrated with an example. Failure data are used to identify the common modes of failure of each termination and thus help direct attention toward the likely location for a failure and a projection of what should be looked for. The data on which this guide is based are included so that as new data become available, the ranking order can be adjusted accordingly. Research done under contract H0166079 by Engineering Services Co. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–168833; paper copy price code A03.

OFR 2(3)–81. Wire Rope Terminations. Volume III. Training and Inspection Manual for the Assembly of Wire Rope Terminations, by John T. Metcalf and F. Matanzo. Aug. 10, 1978. 49 pp. 73 figs. The assembly procedures for nine wire rope terminations used in the mining industry are presented in a format and manner to facilitate training and to provide points where inspection of the termination should be performed. The manual was prepared to be used primarily for field mining operations or training where high-capacity machinery is limited. It is not the intent of this manual to suggest that the procedures presented are those to be used by manufacturers or other commercial enterprises. A different set of procedures may be more appropriate where ideal space and equipment resources are available. The assembly procedures were derived from standard industrial practice, manufacturers' recommendations, and open literature on the subject. These same procedures were used to prepare

test specimens for an extensive series of pull and axial fatigue tests. The results of these tests indicate that these procedures are satisfactory in all respects. The manual is to be used as part of a complete training program. Although a brief glossary is included, there has been no attempt to make this a primer on wire rope. The selection of wire rope termination hardware, like the selection of the wire rope, is a subject not covered by this manual; there are various sources for such hardware and this selection must be done carefully. Research done under contract H0166079 by Engineering Services Co. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Like City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–168841; paper copy price code A05.

OFR 3(1)–81. Oil Shale Mining Environmental Research Program Plan. Volume I. High Funding Level, by F. G. Scott and D. A. Lewis. September 1980. 56 pp. 1 fig. This three-volume report presents a proposed program plan for mining environmental research to be conducted by the U.S. Bureau of Mines in support of industrial oil shale mining and processing. Volume I, one of three research alternatives based on different levels of anticipated funding being considered by the Bureau, documents the high funding level program plan. Research done under contract J0255030 by the Aerospace Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy. Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–168320: paper copy price code A04.

OFR 3(2)–81. Oil Shale Mining Environmental Research Program Plan. Volume II. Mid Funding Level, by F. G. Scott and D. A. Lewis. September 1980. 50 pp. 7 figs. This three-volume report presents a proposed program plan for mining environmental research to be conducted by the U.S. Bureau of Mines in support of industrial oil shale mining and processing. Volume II, one of three research alternatives based on different levels of anticipated funding being considered by the Bureau, documents the midfunding level program plan. Research done under contract J0255030 by the Aerospace Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–168338; paper copy price code A03.

OFR 3(3)–81. Oil Shale Mining Environmental Research Program Plan. Volume III. Low Funding Level, by F. G. Scott and D. A. Lewis. September 1980. 41 pp. 6 figs. This three-volume report presents a proposed program plan for mining environmental research to be conducted by the U.S. Bureau of Mines in support of industrial oil shale mining and processing. Volume III, one of three research alternatives based on different levels of anticipated funding being considered by the Bureau, documents the low funding level program plan. Research done under contract J0255030 by the Aerospace Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill.. and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–168346; paper copy price code A03.

OFR 4–81. Backfilling of Cavities Produced in Borehole Mining Operations, by M. H. Marvin, G. S. Knoke, and W. R. Archibald. August 1979. 85 pp. 30 figs. This report presents the results of a program to develop backfilling techniques to mitigate undesirable effects of hydraulic borehole uranium mining. To prevent ground subsidence and to allow mining of adjacent uraniferous sandstone, large underground cavities, formed during the borehole mining process, can be backfilled. Three techniques that were tested in the laboratory and the field with sand and with sand and 1 wt-pct cement mixtures were bulk dumping of slurry into the boreholes from ground level, slurry injection under water, and slurry injection above the cavity water level. The project was accomplished by equipment preparation and transport, mining operation to generate a full-sized cavity, backfilling operations, and assessment through core samples and subsidence checks. The concentrations of cement mixed with sand were inadequate to bond the sand, and bulk dumping resulted in a 30° angle-of-repose, which was too steep to completely fill the cavity. Both slurry techniques filled the cavity satisfactorily; however, underwater injection is the recommended backfilling technique because the borehole water level does not need to be pumped down during backfilling. The borehole was filled by bulk dumping of slurry. Research done under contract J0285037 by Flow Industries, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–171308; paper copy price code A05.

OFR 5–81. Detection of Lixiviant Excursions With Geophysical Resistance Measurements During In Situ Uranium Leaching, by Robert F. Kehrman. December 1979. 157 pp. 60 figs. As with many new technologies, the rapid growth in solution mining for uranium has created uncertainties regarding the environmental impact of mining operations. In solution

mining, the largest area of concern is the impact of the process on the quality of ground water supplies. A rapid and reliable technique of detecting lixiviant excursions would replace the periodic sampling technique and should provide a more or less continuous monitoring method. To this end, resistivity techniques were evaluated as an alternate means of tracking lixiviant movement. A program was devised with five specific tasks including (1) evaluation of the techniques, (2) development of most promising technique or techniques, (3) field testing of the techniques, (4) testing of the Bureau of Mines probe, and (5) reporting. The result of the analytical and field work is that various resistivity-resistance techniques do provide a means of detecting lixiviant movement in northern Wyoming. Surface and downhole galvanic surveys and controlled source audio magnetotellurics were evaluated. All three techniques showed some degree of success. Research done under Contract No. J0188080 by Westinghouse Electric Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library, and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-171324; paper copy price code A08.

OFR 6(1)-81. Mine Electrical Power Systems. Transients Protection, Reliability Investigation, and Safety Testing of Mine Electrical Power Systems. Vol. I—Transients in Mine Electrical Power Systems, by E. K. Stanek, W. Vilcheck, and A. Kunjara. August 1979. 169 pp. 89 figs. This report contains results of two major efforts related to electrical transients on mine electrical power systems. The first area concerns the use of digital computers to model mine electrical power systems and predict transients or duplicate field recordings of transients. Two existing general purpose circuit analysis programs were used. The first was the TRW Engineering System Simulator or TESS. The second was Electronic Circuit Analysis Program or ECAP. TESS proved to be superior to ECAP in several important characteristics, including system size limitations and modeling nonlinear elements. The second major topic covered in this report is the evaluation of commercially available surge suppression devices. These devices were quite acceptable and guidelines for the selection and placement of surge suppressors were included. The final important item is a listing of the worst-case transients, from a design point of view, for ac and dc utilization systems and ac distribution systems. Research done under grant G0144137 by West Virginia University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.· U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-166761; paper copy price code A08.

OFR 6(2)-81. Mine Electrical Power Systems. Transients Protection, Reliability Investigation, and Safety Testing of Mine Electrical Power Systems. Vol. II—Reliability of Mine Electrical Power Systems, by S. S. Venkata, M. Chinnarao, E. W. Collins, and E. U. Ibok. August 1979. 193 pp. 40 figs. This report describes a comprehensive program of research into the reliability of mine electrical power system components and the resultant reliability of the total system. The research effort encompassed analytical models and laboratory and field testing. The analytical work included definitions of terms, fail rate functions and distributions, failure rate estimation and techniques, and procedures for theoretical reliability assessment. One of the primary mine power system components was the ac-molded case circuit breaker. This device is known to have low reliability and hence an unfavorable impact on mine safety and productivity. Ac-molded case circuit breaker reliability was studied analytically, laboratory tested, and field monitored. A similar three-pronged effort was made to study the reliability of undervoltage relays-releases. Particular emphasis was placed on new solid-state undervoltage relays. The reliability of bulk power components, such as trailing cables, motors, control gear, and other equipment, was assessed by gathering maintenance records from active mines. These data were compared to similar records from other industries. The work was extended to include the reliability, availability, maintainability, and safety of these components. Research done under grant G0144137 by West Virginia University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-166779; paper copy price code A09.

OFR 6(3)-81. Mine Electrical Power Systems. Transients Protection, Reliability Investigation, and Safety Testing of Mine Electrical Power Systems. Vol. III—Optimal Design of Mine Electrical Power Systems, by M. M. Hassan and E. K. Stanek., August 1979. 53 pp. 22 figs. This report describes the analysis tools developed at West Virginia University that can be implemented to optimally design coal mine electrical systems. The basic analytical tools for all power systems are the load-flow and short-circuit analysis. Well-known programs have been developed for analysis of ac transmission and distribution systems, but thev are not applicable to a system that has combined ac-dc distribution, such as a coal mine power system. Furthermore, the topology of a coal mine electrical system changes continuously owing to the movement of locomotives on the track. In the first section of this report, algorithms for carrying out load-flow and short-circuit analysis of a coal mine electrical system are described. Results from the study of a typical coal mine system are presented. In the second section, a method is described to optimally size power cables for cyclic loads. This method is based on the development of a thermal-electric model for a low-voltage power cable. Results from experimental verification of the model are also presented. Research done under grant G0144137 by West Virginia University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno,

Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–166787; paper copy price code A04.

OFR 6(4)–81. Mine Electrical Power Systems. Transients Protection, Reliability Investigation, and Safety Testing of Mine Electrical Power Systems. Vol. IV—Use of Programmable Calculators in Mine Power Systems Design and Analysis, by E. K. Stanek and Marc Cobert. August 1979. 113 pp. 10 figs. This report describes software developed for programmable calculators that is useful in the analysis and design of mine electrical power systems. The programs are equally useful for any industrial or commercial power system. All programs are written for both the HP-97 and TI-59 programmable calculators. Listings of both versions of the 12 programs that were developed appear in the report; each program can be broken into 2 groups. The first group encompasses design-oriented programs and the second encompasses analysis programs. For each program the following items are provided: a description of the program's capabilities, the solution technique used, instructions on how to use the program, a worked-out example with data and results, and listings of the programs for the HP-97 and TI-59 programmable calculators. Typical problems that can be attacked with these programs include ground bed design, selection of contactor size, fuse size, relay settings, instantaneous overcurrent trip settings for trailing cables, allowable cyclic cable loading, short circuit analyses, prediction of transient voltages, and others. Research done under grant G0144137 by West Virginia University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–166795; paper copy price code A06.

OFR 6(5)–81. Mine Electrical Power Systems. Transients Protection, Reliability Investigation, and Safety Testing of Mine Electrical Power Systems. Vol. V—Periodic Inspection of Mine Electrical Power Systems, by E. K. Stanek, M. M. Hassan, Y. C. Chou, and H. Shamash. August 1979. 113 pp. 55 figs. This report presents the results of an investigation into the feasibility of periodically measuring parameters of the insulation for a mine electrical power system to detect incipient faults. The variety of insulation parameters evaluated included insulation resistance, dissipation factor, power factor (versus applied voltage), current harmonics, leakage current, infrared radiation, as well as certain circuit breaker parameters and tests. To augment field tests, a program of accelerated life testing was also carried out. Apparent inconsistencies in data were identified as the result of environmental effects, primarily temperature and relative humidity. A series of environmental tests were conducted to develop correction factors that allow reference of measured parameters to standard conditions. A portable data collector was developed to aid in the accurate collection and analysis of laboratory and field data. It was concluded that insulation deterioration can be measured and failure predicted with reasonable confidence, and that most of the tests are impractical in the field although useful in the laboratory. Infrared sensing, insulation resistance, and dissipation factor are the best insulation field tests when portability is taken into account. Research done under grant G0144137 by West Virginia University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–166803; paper copy price code A06.

OFR 7–81. Intrinsically Safe Supporting Research, by Zsuzsanna Zborovszky. April 1980. 148 pp. 32 figs. The objective of this report is the evaluation of the tentative document entitled "Test Requirements for Instruments or Apparatus to be Considered for MESA Intrinsically Safe Certification." The evaluation is to cover only certain portions pertinent to gas ignition testing (portions dealing with coal dust ignitions are excluded). Wherever it seemed necessary, supporting data were generated to prove or disprove questionable points. Research done under Contract No. J0177111 by Denver Research Institute. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–179384; paper copy price code A07.

OFR 8–81. Feasibility of Control System Automation for a Drum Head Continuous Mining Machine, by John E. Lambert and Phillip Mighdoll. Aug. 10, 1979. 97 pp. 15 figs. Automatic control of drum head continuous mining machines was investigated as a means of reducing respirable dust generated and operator variability. Literature survey, manufacturer interviews, and mine visits were the major information sources. Technically feasible automation concepts were identified to control sump and shear rates, cutter head elevation limits, and sumping distance. These are the elements of a programed cutting cycle that maintains peak penetrating force on the cutter, to maximize depth of cut, and therefore reduce dust generation. Based on the industry surveys, successful underground hardware demonstrations must be completed to stimulate the market demand for these advanced control features. Research done under contract J0188084 by Booz-Allen & Hamilton Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany,

Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–168361; paper copy price code A05.

OFR 9–81. Trolley Line Power Transfer to Vehicles, by Andrew St. Amant. July 31, 1980. 80 pp. 8 figs. This report reviews the first three investigative and concept generation phases and details the task performance of phase IV of a trolley line power transfer to vehicles. This last phase integrated the most promising concepts from phases I, II, and III into a prototype detailed design, which was manufactured and then tested on a mine locomotive. The concepts developed during the first three phases provided "Improved Pole Tracking," automatic "Rapid Pole Retraction" in the event of dewirement, and servooperated "Remote Pole Repositioning" on the trolley wire. The appendix of the report supplies detailed information for the design and construction of the prototype system, which is comprised of an RCB (Remotely Controlled Base subassembly), and RCL (Remote Control Level subassembly), and an SAU (Servo Amplifier Unit) subassembly. Research done under Contract No. J0377057 by MBAssociates. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–178873; paper copy price code A05.

OFR 10–81. Development of Dual Input/Dual Purpose Power Converter for Trolley Wire Operation, by D. A. Paice, D. S. Kimmel, and R. P. Putkovich. October 1979. 62 pp. 27 figs. A power supply to operate fluorescent or mercury vapor lamps from 300-volt dc coal mine trolley wires was developed for the Bureau of Mines. A high-frequency regulated inverter unit incorporates ballasts for a mix of lamp loads up to 650 watts. For 600-volt trolley systems an additional power converter unit was developed to step down the dc voltage to 300 volts for the inverter unit. Both units have operated in a working coal mine for more than 12 months without need of servicing. The lamp load included two 100-watt mercury vapor head lamps and six 75-watt fluorescent lamps. Research done under Contract No. H0166031 by Westinghouse Electric Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–179434; paper copy price code A04.

OFR 11–81. Exploratory Studies of Flame and Explosion Quenching. Volume II. User's Manual for Flame Propagation Code for Premixed Laminar Heterogeneous Systems, by Brent A. Whiting, L. Douglas Smoot, and Vern J. Crandall. Aug. 31, 1979. 296 pp. 4 figs. This report presents a computer code for predicting the characteristics of laminar, premixed, propagating, coal dust flames. The code is the result of a research program to improve understanding of the mechanisms of coal dust flame propagation and extinguishment. This work is a part of a larger Bureau of Mines research program on control of coal dust explosions in coal mines. This program, initiated in June 1972, comprised experimental coal dust flame measurements, together with development of the theory for laminar, premixed coal dust flames. Details of extensive experimental results for methane-air, coal dust-air, and coal dust-air-suppressant tests are documented in volume I of this report. The theoretical basis for flame was also reported in volume I, together with the solution techniques and a summary of extensive code predictions and comparisons with experimental measurements. Research done under grant G0177034 by Brigham Young University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–183949; paper copy price code A13.

OFR 12–81. Investigation of the Effects of Weak Floor Conditions on the Stability of Coal Pillars, by John D. Rockaway and Richard W. Stephenson. July 1979. 227 pp. 72 figs. Failure of a mine floor supporting coal pillars frequently occurs when the subcoal strata include "underclays" or other low-strength strata. The failure process has been studied to define the response of these materials to applied coal pillar loads and to determine the applicability of bearing capacity analysis to evaluate unsafe conditions. An investigation was conducted of both the intact and in situ geotechnical properties of the subcoal strata and the installation of floor movement monitoring instrumentation. The results of these studies indicated that both the shear strength of the underclay and the stratigraphy of the subcoal strata must be considered in the analysis. The shear strength was the major controlling factor determining the ultimate load-carrying ability of the materials, but the thickness and stratigraphic position of the weak layers influenced the mechanism of the failure process. Research done under Contract No. J0155153 by University of Missouri-Rolla. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo.. Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–181109; paper copy price code A11.

OFR 13–81. Statistical Studies—Metal/Nonmetal Mine Fatality Studies, by Thomas E. Doerfler. July 1980. 48 pp. 3 figs. This report contains an analysis of information and data related to the occurrence of fatalities due to major disasters in metal-nonmetal underground mines. Standard statistical methods were used to estimate the probability of occurrence of major disasters, and to examine the relationship of disasters to injury statistics published annually. Research done under Contract No. J0395086 by Arthur D. Little, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–167561; paper copy price code A04.

OFR 14–81. The Mechanism of Attachment of ^{218}Po(RaA) to Monodispersed Aerosols, by Philip K. Hopke and James J. Stukel. Jan. 31, 1980. 155 pp. 19 figs. A systematic study of the mechanism of interaction of ^{218}Po(RaA) formed by the decay of ^{222}Rn with airborne particulate matter has been made. The rate of attachment of RaA to particles in the diameter range of 0.1 μm to 10.0 μm was measured as a function of particle size, concentration, and composition, radon concentration, time of interaction, relative humidity, and temperature. It was found that under the conditions in these experiments the attachment rate was proportional to the square of the particle diameter and varied with temperature and relative humidity. The composition of the particles apparently has no effect on the attachment. The variation in attachment rate was related to a sticking probability coefficient of approximately 0.02 that varies systematically with temperature and humidity. In addition, the rate of deposition of RaA on the walls of the attachment kinetics system was measured and also found to change with temperature and relative humidity. Research done under grant G0264010 by University of Illinois at Urbana-Champaign. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–166308; paper copy price code A08.

OFR 15–81. Development of a Personal CO_2 Detector, and a CH_4 Detector, by Irvin G. Burough. August 1979. 125 pp. 61 figs. This report describes four handheld CO_2 detectors and three handheld CH_4 detectors that were designed and manufactured for in-mine safety use. The detectors incorporated an optical-electronic analyzer design in which exceptional zero stability is achieved by pressure modulation of the sample gas and thus eliminating the need for daily calibration. The stability and miniature design of the CO_2 and CH_4 detectors provide practical instruments suitable for routine safety inspections. The report includes the theory and design of the instruments as well as studies of gas-pressure modulation by a piezoceramic-driven resonator. Research done under Contract No. H0377096 by Andros Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–163982; paper copy price code A07.

OFR 16–81. Development of a Lightweight Air Powered Drill Tool for Probe Drilling in Anthracite Mines, by William H. Hamilton and Jerry Brace. December 1979. 38 pp. 44 figs. This report describes the results and conclusions of the development and evaluation of a unique concept for a lightweight air-powered drill tool for probe drilling in anthracite mines. A concept model of the lightweight air-powered tool was constructed and evaluation testing conducted at the Kocher Coal Co. Porter Tunnel Mine. The unique anchoring method proved to be extremely satisfactory and the overall lightweight air-powered drill tool concept proved feasible. Based on the results of the concept model testing, two prototype production units were designed and manufactured. These prototype units met all design requirements of lightweight, portability, drilling controllability, structural integrity, and miner acceptance. The need for a better bit and drill steel system, however, became evident during testing and recommendations are made for further investigation and development of a bit and drill steel system suitable for this application. Research done under contract H0282044 by Hamilton Engineering, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–166282; paper copy price code A03.

OFR 17-81. Design and Development of Protective Canopies for Underground Low Coal 48" and Under, by Peter P. Kopas. Mar. 1, 1980. 89 pp. 5 figs. This report comprises the study, analysis, fabrication, and testing for canopies on roof bolts and shuttle cars in coal seams under 48 inches high. The report includes 31 drawings showing the assembly and details of a roof bolter and 27 drawings showing the assembly and details of a shuttle car. Research done under Contract No. H0188014 by Kogen Industries, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beck-

ley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–167553; paper copy price code A05.

OFR 18–81. Preliminary Design and Cost Estimate for Field Worthy Simple Featured MMRDM Based on a Prototype Beta Attenuation/Filter Tape System Developed Under Contract Number H0166097, by Pedro Lilienfeld. May 16, 1980. 96 pp. 20 figs. This report presents a design and cost investigation for several alternative versions of a field-worthy mining machine-mounted respirable dust monitor. Three main design variations are light scattering sensing, Beta-filter tape sensing, and a combination of the two methods. Eventual instrument production costs as a function of design complexity are tabulated. Cost estimates for the development and field testing of field-worthy prototypes are also presented. A general discussion on the technical aspects of these design alternatives is included following a modular-hierarchical approach of progressive complexity. Research done under Contract No. J0199163 by GCA Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–166324; paper copy price code A05.

OFR 19–81. Improved Fire Safety of Coal Mine Hydraulic Systems, by F. C. Kohout, E. N. Ladov, and D. A. Law. March 1979. 155 pp. 52 figs. An advanced water-in-oil emulsion hydraulic fluid has been developed that meets defined laboratory performance criteria and gave fully satisfactory results in a 1-year underground mine test in two continuous miners. A novel method of monitoring fluid water content was demonstrated and incorporated into a test kit for use at or near the mine site. Test fluid fire resistance integrity as measured by the Mining Safety and Health Administration schedule 30 procedure was maintained during the test, and important fire resistance test variables were identified. Research done under Contract No. H0357108 by Mobil Research and Development Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–166852; paper copy price code A08.

OFR 20–81. Combined Fire/Rot Retardant Treatment for Wood Mine Timber, by Bernard Baum and William Holley. October 1978. 105 pp. 3 figs. Combined preservative, and fire-retardant systems were pressure impregnated into Douglas fir and Ponderosa pine samples and evaluated for decay, flammability, and mechanical properties. The objective was to identify cost-effective systems for use with mine timber, and to provide an information and data base from which Federal code regulations could be established. Thirty systems, based on combinations of commercially available preservatives and fire-retardent impregnants and coatings, were applied to Douglas fir samples and evaluated for decay and flammability. The 10 most promising systems were applied to both fir and pine and reevaluated for decay and flammability before and after water leaching. The five best systems were evaluated in the laboratory using both pine and fir including flame spread, smoke density, toxic gases, decay, compressive strength, flammability after artificial weathering, and cost. All systems had acceptable toxic gas levels and smoke densities, but flame spread was only borderline acceptable for most of the samples tested. Recommendations are made for further large-scale testing using the two best systems. Research done under Contract No. J0166068 by Springborn Laboratories, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–166381; paper copy price code A06.

OFR 21(1)–81. A Study of Hazardous Openings to Abandoned Underground Mines in Western Colorado. Volume I. Final Report, by R. S. Dewey, L. A. Robbins, L. D. Oehler, T. L. Reed, and P. A. Bilzi. April 1980. 218 pp. 20 figs. The purpose of this study was to assess the various aspects of public safety related to the thousands of abandoned or inactive underground mines found throughout western Colorado. Review of available published mine inventories yielded data on over 8,000 abandoned underground mines. A random sample of 200 mines was then selected for field visits representative of mining activity in Colorado. Of the 200 mines visited, 20 mine openings representative of varying geologic, environmental, access, and mining conditions were selected for detailed low-cost safeguard application. Volume I comprises descriptions of these safeguards, presented in narrative, itemized labor-materials-equipment tabulations, and illustrations. Research into the regulations of mine closure and safeguards was also undertaken to determine jurisdiction of public lands. Recommendations are suggested to improve the awareness and ability to continue this program into an implementation stage. Research done under contract J0295020 by Skelly and Loy. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington. D.C. Order ONLY from NTIS: PB 81–177909; paper copy price code A10.

OFR 21(2)–81. A Study of Hazardous Openings to Abandoned Underground Mines in Western Colorado. Volume II. Final Appendix A Through L, by R. S. Dewey, L. A. Robbins, L. D. Oehler, T. L. Reed, and P A. Bilzi. April 1980. 370 pp. 62 figs. The purpose of this study was to assess the various aspects of public safety related to the thousands of abandoned or inactive underground mines found throughout western Colorado. Review of available published mine inventories yielded data on over 8,000 abandoned underground mines. A random sample of 200 mines was then selected for field visits representative of mining activity in Colorado. Volume II contains quadrangle maps showing the locations of mines in counties, in alphabetical order, A through L. Research done under contract J0295020 by Skelly and Loy. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior Washington, D.C. Order ONLY from NTIS: PB 81–177917; paper copy price code A16.

OFR 21(3)–81. A Study of Hazardous Openings to Abandoned Underground Mines in Western Colorado. Volume III. Final Appendix M Through W, by R. S. Dewey, L. A. Robbins, L. D. Oehler, T. L. Reed, and P. A. Bilzi. April 1980. 334 pp. 43 figs. The purpose of this study was to assess the various aspects of public safety related to the thousands of abandoned or inactive underground mines found throughout western Colorado. Review of available published mine inventories yielded data on over 8,000 abandoned underground mines. A random sample of 200 mines was then selected for field visits representative of mining activity in Colorado. Volume III contains quadrangle maps showing the locations of mines in counties, in alphabetical order, M through W. Research done under contract J0295020 by Skelley and Loy. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–177925; paper copy price code A15.

OFR 22–81. Investigation of the Mechanics of Mine Acid Formation in Underground Coal Mine Drainage, by Fraser Walsh. November 1980. 122 pp. This study investigates the kinetics and the mechanics of the reactions that produce acid in coal mine drainage using fresh mine face samples from five Appalachian coal mines. The results of the study show that pyrite weathering is based on oxidation in the presence of water where the oxidants can be either ferric iron or oxygen. Iron bacteria, especially *T. ferrooxidans,* catalyze the rate of pyrite weathering by a factor of 3. An increase in initial iron concentration in a system that models the mine environment acts to inhibit bacterial catalysis of pyrite weathering. Research done under Contract No. J0387215 by ECO, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–179418; paper copy price code A06.

OFR 23–81. Mine Grounding Systems. Evaluation of In-Mine Grounding System and Codification of Ground Bed Construction and Measurement Techniques, by Wils L. Cooley and Robert L. McConnell. June 30, 1979. 300 pp. 155 figs. The report describes two major grounding topics: mine ground systems and ground-check monitors. Performance characteristics of ground-check monitors for high-voltage surface mine distribution cables and low-voltage underground mine trailing cables are evaluated. Over 20 commercially available monitors are studied to determine their utility. Several monitoring concepts are incorporated into an unusual monitor design; the prototype is described in detail. A comparative study of the effectiveness of several alternate methods of grounding surface mine equipment supports the system currently proposed by MSHA. An instrument design to measure earth voltage gradients is described, as well as an instrument design for measuring the effectiveness of dc haulage current return systems. An extreme analysis is made of techniques for measuring earth resistivity and resistance of safety ground beds. Electrolytic corrosion studies of earth electrodes are reported extensively also. Research done under Grant No. G0144138 by West Virginia University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–178881; paper copy price code A14.

OFR 24–81. Electrical Practices in Metal/Non-Metal Mines and Mills. Old Electrical Power Systems, Equipment, and Practices, by David Bendersky, Vernon W. Klein, and Daniel R. Keyes. October 1980. 102 pp. 86 figs. This report covers a technical and economic investigation of old electrical power systems, equipment, and practices being used in the metal-nonmetal mining industry. The principal sources of information were the MSHA district offices, visits to representative mines and mills, equipment manufacturers, and the literature. A list of 85 mines and mills, submitted by the MSHA districts as candidates for this study, is given and their characteristics are analyzed. The electrical power systems and practices at the 10 mines and 9 mills that were visited are described. The principal areas that do not conform to standard electrical practices are discussed with emphasis on the safety aspects of these practices. The costs to update electrical power systems and practices in metal-nonmetal mines and mills are given. The principal findings of

the study are summarized and recommendations are submitted. Research done under Contract No. J0387203 by Midwest Research Institute. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–179400; paper copy price code A06.

OFR 25–81. Development and Validation of a Miner's Instructional Procedure for Improved Safety Training, by Kay E. Goldberg and Roger Silliman. July 1980. 37 pp. This report presents the results of a study conducted by the Bureau of Mines to develop and evaluate a training workshop for mine safety training personnel. The workshop was based on the Instructional Development Institute, which has been used for nearly 10 years to train educators and administrators in the application of a nine-step model for defining, developing, and evaluating instruction. Recommendations for further research are included. Research done under Contract No. H0188052 by University of Southern California. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–179426; paper copy price code A06.

OFR 26–81. 1978 Mineral Investigations in the Misheguk Mountain and Howard Pass Quadrangles, Alaska, by Uldis Jansons and Mary Ann Parke. 1980. 295 pp. 38 figs. In 1977–78 the U.S. Bureau of Mines and the U.S. Geological Survey formed study teams to investigate mineralization and geology related to mineralization in the National Petroleum Reserve in Alaska (NPR-A) The work area is north of the confluence of Driftwood Creek and the Utukok River, in the southwestern part of the NPR-A. The 1977 fieldwork consisted of geological mapping, geochemical sampling, aerial geologic reconnaissance, and site specific investigations and sampling. During the 44-day 1978 field season, Bureau professionals prospected and sampled areas where results of the 1977 geochemical survey indicated the presence of anomalously high metal concentrations. The prospecting consisted primarily of creek traverses in search of mineralized rock that could account for the geochemical anomalies. Stream sediment samples were collected from tributaries of the geochemically anomalous drainages. The report summarizes the 1978 Bureau fieldwork and presents analytical results. Research done by Alaska Field Operations Center. Available for reference at the Office of the Director, Division of Mineral Land Assessment, Bureau of Mines, Washington, D.C.; Bureau of Mines facilities in Anchorage, Fairbanks, and Juneau, Alaska; 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 27–81. Mineral Investigations in the Porcupine River Drainage, Alaska, by James C. Barker. March 1981. 201 pp. 31 figs. Between 1976 and 1978, the Bureau of Mines conducted a mineral resource investigation in the Porcupine River drainage of northeastern Alaska. The study area is divided into three generalized geologic terrains. Potential deposit types of each terrain are described as they are indicated by mineral occurrences and other data. Research done by Alaska Field Operations Center. Available for reference at the Office of the Director, Division of Mineral Land Assessment, Bureau of Mines, Washington, D.C.; Bureau of Mines facilities in Anchorage, Fairbanks, and Juneau, Alaska; 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 28–81. Preliminary Evaluation of Geochemical Data From the Proposed Chukchi Imuruk National Reserve, Alaska, by Uldis Jansons. March 1981. 8 pp. 2 figs. Water and waterborne sediment samples from the proposed Chukchi Imuruk National Reserve were analyzed for the Bureau of Mines. The antimony, bismuth, gold, lead, silver, uranium, and zinc contents of the sediment samples were studied to determine if samples with anomalous element concentrations are present, to outline the distribution of the anomalous samples, and to evaluate the use of the geochemically anomalous samples, as indicators of known and potential zones of mineralization. Extensive uranium and zinc geochemical anomalies were identified in the southeastern part of the proposed reserve. Less extensive geochemical anomalies of gold and other elements were also identified. Some anomalous samples come from areas of known mineralization and suggest that the trends extending into the proposed withdrawal may have associated mineralization. Research done by Alaska Field Operations Center. Available for reference at the Office of the Director, Division of Mineral Land Asessment, Washington, D.C.; Bureau of Mines facilities in Anchorage, Fairbanks, and Juneau, Alaska; 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 29–81. Tungsten Investigations Near VABM Bend, Eastern Alaska, by Jeff Foley and James C. Barker. March 1981. 24 pp. 5 figs. Numerous scheelite occurrences in the Charley River area of east-central Alaska suggest the existence of a broad geographic zone with a potential for economic deposits of tungsten. The trend strikes northwesterly across a region of diverse geology from the Seventymile district to Pinnell Mountain. Tungsten mineralization occurs on a tributary of Crescent Creek in the Charley River drainage as disseminated grains and aggregates up to 2 cm across in banded, hornfelsic calc-silicates; disseminated grains in biotite-quartz monzonite; and concentrations in siliceous veins less than 1 cm across in leucocratic, igneous rocks. Weathering of these rocks has led to concentration of scheelite in placer deposits. Research done by Alaska Field Operations Center. Available for reference at the Office of the Director, Division of Mineral Land Assessment, Washington, D.C.; Bureau of Mines facilities in Anchorage, Fairbanks, and Juneau, Alaska; 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 30–81. An Evaluation of Leaky Feeder Communication in Underground Mines, by D. T. Updyke, W. C. Muhler, and H. C. Turnage. June 1980. 104 pp. 40 figs. The objective of this project was to develop technical data and evaluate performance and utility of leaky feeder communications systems currently used in U.S. underground mines. The desired information was obtained principally through on-site surveys. Six of the seven mining companies known to be using leaky feeder communications were visited. This report covers the findings of these surveys. In addition, the report provides a brief background summary of mine communications, a technical discussion of leaky feeder systems, and conclusions and recommendations based on the results of the survey. Research done under Contract No. J0199048 by Atlantic Research Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–194466; paper copy price code A06.

OFR 31–81. Development and Evaluation of an Illumination System for Continuous Miners That Are Utilized in the Extraction of Trona, by William F. Hahn and Stanley J. Ryba. Mar. 25, 1980. 73 pp. 31 figs. This report describes two illumination system designs and their demonstration and evaluation on a Jeffrey 120HR continuous-mining machine in an active trona mine in Wyoming. Research done under Contract No. J0387202 by Booz, Allen & Hamilton Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–194474; paper copy price code A04.

OFR 32–81. Electromagnetic Fields in Mine Environments, by James R. Wait and David A. Hill. May 1, 1980. 448 pp. 362 figs. This report comprises the total productivity of a series of related investigations performed during 1971–79. The first phase concentrated on the analytical studies of techniques relevant to mine rescue. The second phase dealt with the fundamental character of how electromagnetic waves propagate in mine tunnels. The third phase was devoted to the analyses of various specific geophysical engineering problems. The fourth phase concerned the general subject of nondestructive testing of wire ropes used for mine hoists. Research done under contract J0199115 by Institute for Telecommunication Science. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; 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 33–81. Detection Instrumentation for Cable Shield Defects, by James R. Cosby, Gerard B. Gilbert, and Jay H. Stoudenmire. Aug. 29, 1980. 50 pp. 6 figs. This report describes work performed for the Bureau of Mines to evaluate available portable instruments for their effectiveness in detecting and locating damaged metallic shields in types SHD and SHC cables. A second phase of the program covers several instruments of a type that could prove effective and were purchased for modification and testing to verify their performance. Research done under Contract No. J0188081 by the Bendix Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–194540; paper copy price code A03.

OFR 34–81. Development of a Manually Operated Rescue Team Vehicle, by Mervin D. Marshall. Feb. 2, 1978. 183 pp. 55 figs. A quick-reaction, mine-permissible rescue vehicle (MERV) was developed for use by rescue teams. The MERV, a six-wheeled, battery-powered unit with life support equipment and instrumentation, is designed for a two-person team with provisions for handling two victims or tools in a trailer. The MERV, which is 100 inches long, 56 inches wide, and a maximum height of 34 inches, can be lowered down most mine shafts and has clearance to travel mine railways. The MERV has power to all six wheels that can be transmitted separately to either or both sets of wheels. Low-pressure, high-traction tires give the vehicle the ability to handle soft, muddy mine floors, flooded areas and significant obstacles, and can negotiate a 45° grade. Power and life support are sufficient for a 4-hour mission. The life support system is a commercially available, approved unit currently used by MSHA rescue personnel. A payout wire system provided communication between the MERV and home base over a distance of 10,000 feet. On-board monitoring of carbon monoxide, methane, and oxygen is provided, with master and individual alarms to warn of gas concentrations outside preset limits. A lightweight, water-tight trailer was developed for carrying victims or hauling tools and equipment. Research done under Contract No. H0122063 by Mine Safety Appliances Co. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–194482; paper copy price code A09.

OFR 35–81. Reclamation and Pollution Control: Planning for Smaller Sand and Gravel Mining Operations, by Paul T. Banks, Robert E. Nickel, and Donald A. Blome. Jan. 31, 1981. 159 pp. 44 figs. This guide is designed for use in planning pollution control and reclamation activities on small sand and gravel operations. The purpose is to assist operators in selecting environmentally desirable pollution control and reclamation procedures based on a particular mining situation. The guide includes information on interpreting physical and cultural factors that must be considered in planning and implementing a mining and reclamation program, achieving environmental protection objectives, and improving community-industry cooperations. A summary of State laws and a list of additional readings on the subject are included. Research done under Contract No. J0199052 by Hittman Associates, Inc., and Interstate Mining Compact Commission. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–190241; paper copy price code A08.

OFR 36–81. Preliminary Report on the Mineral Potential of the Alaska Peninsula, by Eric Hanson, Greg Sherman, and Jeff Knaebel. April 1981. 39 pp. 7 figs. This report summarizes the mineral potential of the Alaska Peninsula and adjacent islands from Kamishak Bay westward to False Pass. Despite sporadic mining, prospecting, and oil drilling since the late 1800's, the area remains essentially unprospected. Geologically, the Alaska Peninsula is an uplifted island arc that has had a long and continuing history of igneous activity. Consequently, the area has a high potential for geothermal energy and sulfur deposits are common. The Alaska Peninsula also has a favorable environment of copper porphyry, copper-molybdenum, and several other types of deposits of metallic minerals. Gold was mined on Unga and Popof Islands and prospects containing gold, silver, copper, lead, zinc, iron, and titanium are reported. The Alaska Peninsula is not considered highly favorable for uranium but has some potential that remains essentially untested. Research done under Purchase Order P4670242 by Resource Associates of Alaska, Inc. Available for reference at Bureau of Mines facilities in Anchorage, Fairbanks, and Juneau, Alaska; and Office of the Director, Division of Mineral Land Assessment, Bureau of Mines, 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 37–81. Mineral Investigations of Certain Lands in the Eastern Brooks Range, 1978, by James C. Barker. April 1981. 288 pp. 16 figs. This is an interim report on the findings of a mineral resource study in the eastern Brooks Range, Alaska, involving 4,300,000 acres of lands. The study area is divided into five geologic terrains and limited field work was undertaken during the 1976–78 field seasons. A sample survey was undertaken throughout the major portion of the project area to more adequately define regions of mineral potential and 1,109 stream sediments and 85 rock samples were analyzed. Select anomalies and prospects were field checked. Further multielement analyses of these samples are being made by the U.S. Department of Energy and will be reported separately by that agency. Research done by Alaska Field Operations Center. Available for reference at Bureau of Mines facilities in Anchorage, Fairbanks, and Juneau, Alaska; and Office of the Director, Division of Mineral Land Assessment, Bureau of Mines, 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 38–81. Procedures for the Performance Evaluation of Gas Detection Devices Including Preliminary Test Methods, by Jeffrey S. Newman. May 23, 1980. 251 pp. 18 figs. This report establishes a methodology for the evaluation of gas detection devices and is the result of a critical investigation into the basic principles defining gas detector performance. A scheme is presented to evaluate the performance of a test sample of gas detectors based on the detector type and intended application. Test procedures, worksheets, test apparatus, glossary, and statistical methods for handling test data are given. In addition, evaluation standards and test parameters are identified. It is intended for this report to serve as a comprehensive framework for the eventual certification of all gas detectors for mine applications. A plan is proposed and recommended for the quantification and implementation of evaluation standards for gas detection device certification. Research done under Contract No. J0387211 by Factory Mutual Research Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–194961; paper copy price code A12.

OFR 39(1)–81. Environmental Factors Affecting Surface Mining of Steeply Pitching Coal Seams. Volume I/Overview, by Grant R. Brown, William J. Douglas, Edward T. Schroeder, David H. Dike, Albert H. Hirsch, and John T. Urban. April 1980. 131 pp. 11 figs. With renewed demand for coal to supply today's energy needs, many coal mining operations are being developed that previously would have been deemed uneconomic. One of the most challenging areas of coal recovery is coal seams that pitch in excess of 25°. Thus, the Bureau of Mines conducted in-depth analyses of the environmental, operational, and reclamation problems in terms of the resource potential associated with the surface mining of steeply pitching coal seams. This report presents the analyses of five surface mines located in three geologically distinct basins of the United States. Research done under Contract No. J0199006 by Ketron, Inc., and WAPORA, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S.

Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-194987; paper copy price code A07.

OFR 39(2)-81. Environmental Factors Affecting Surface Mining of Steeply Pitching Coal Seams. Volume II /Site Analyses, by Grant R. Brown, William J. Douglas, Edward W. Schroeder, David H. Dike, Albert H. Hirsch, and John T. Urban. April 1980. 129 pp. 52 figs. This report provides guidance to determine the environmental impacts associated with the surface mining of steeply pitching coal seams. Four additional issues discussed are time and motion studies of those coal mining systems employed in mining seams that pitch in excess of 25°, assessment of those mining techniques, development of rationale for the mining methods employed, and identification of the reclamation practices and determining whether they are in compliance with appropriate and Federal and State regulations. Research done under Contract No. J0199006 by Ketron, Inc., and WAPORA, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-194995; paper copy price code A07.

OFR 40(1)-81. Coal Mine Equipment Population Characterization and Protective Structure Status. Volume I, by Gary R. Gavan, C. William Harpur, Louis Schaffer, and Jack L. Woodward. Oct. 20, 1978. 222 pp. 17 figs. This report presents the results of a research project that gathered detailed information on the composition of the population of mobile equipment used in U.S. coal mines. A computerized data bank containing over 19,000 pieces of coal mine equipment in use in 1976 was prepared with a data retrieval program. Operator protective structure technology is reviewed and field problems experienced with rollover protective structures are discussed. Research done under contract J0366016 by Woodward Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-194946; paper copy price code A11.

OFR 40(2)-81. Coal Mine Equipment Population Characterization and Protective Structure Status. Volume II, by Gary R. Gavan and Ken Winters. Mar. 15, 1979. 125 pp. 20 figs. This report presents the documentation and User's Manual for a data retrieval and report generation computer program, that is described in volume I. The program operates on a data base containing over 19,000 pieces of coal mine equipment in use in 1976. Research done under contract J0366016 by Woodward Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-194953; paper copy price code A07.

OFR 41-81. Analytical Modeling of Coal Mine Roof Behavior, by R. T. Langland. October 1978. 99 pp. 73 figs. Using a finite element computer code developed for the Bureau of Mines to calculate roof sag, convergence, roof bolt load change, and standard engineering property information, a comprehensive series of three-dimensional calculations at three different sites in a room-and-pillar coal mine were performed. The calculated results were then compared with experimental results obtained from an extensive in-site field measurement program. General agreement was obtained between the analytical and field results showing that three-dimensional, finite element modeling of mining can be an extremely useful tool for understanding mine behavior. A series of parametric studies were also performed that examined the effects of changing the viscoelastic time parameters, varying the preload on the bolts, and changing the effective stiffness of the bolts. Research done under Contract No. H0242043 by Lawrence Livermore Laboratory. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities,, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: UCRL-52586; paper copy price code A05.

OFR 42-81. An Interactive Computer System for Evaluating Coal Mine Illumination, by Mathematical Applications Group, Inc. December 1978. 15 pp. 3 figs. A computer system for calculating the illumination on coal mine surfaces due to machine-mounted lights is described. Utilizing numerical models of mining machinery and measured data on luminaire output characteristics, the program computes the foot-candle levels incident on the mine entry surfaces for any desired machine-luminaire-entry configuration, and shadowing effects of the machine are taken into account. Results are provided at 2-foot intervals on the face, left and right walls, floor, and roof. The system operates, interactively from a Tektronix 4014 graphics terminal which handles all input-output functions. The software is installed on a Cyber 74 computer that communicates with the terminal by a telephone line. Research done under contract S0271041. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety

Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–195687; paper copy price code A02.

OFR 43–81. Centrifugal Model Analysis of Coal Waste Embankment Stability, by Frank C. Townsend, Deborah J. Goodings, Andrew N. Schofield, and Mosaid M. Al-Hussaini. August 1980. 118 pp. 71 figs. Centrifugal model embankments with varying geometries and materials were constructed of coal waste material, accelerated from 100 to 120 times Earth's gravity, and subjected to various throughflow rates until failure occurred. Complementary laboratory tests were performed on the waste materials to obtain strength and permeability parameters for analytical calculations to predict observed centrifugal model behavior. Failures in the form of deep-seated failure, or erosion and sediment transport or a combination of both, occurred in model embankments with IV:1–1/2H and IV:2H slopes when the phreatic surface due to seepage exited on the downstream slope. Positive seepage control, that is, a toe drain, successfully prevented sloughing and failures. Slope stability analyses agreed conservatively well with observed model performance. Factors of safety ranged from 0.7 to 1.02 at the instant of failure for models with retrogressing slips as compared with 1.05 to 1.7 for stable embankments. These models verified existing criteria of a minimum safety factor of 1.3 and the necessity of positive seepage control. Research done under Contract No. H0282018 by U.S. Army Engineer Waterways Experiment Station. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–194524; paper copy price code A06.

OFR 44–81. Improved Tire Inspection for Large Mobile Mining Equipment, by Robert M. Jones, William G. Freeman, Monty L. Christo, and Larry Attebery. September 1979. 140 pp. 40 figs. Guidelines were developed to provide mine management with recommended tire inspection procedures for operating, maintenance, and supervisory personnel. These guidelines were developed from accident statistics that indicated when, how, and where the accident occurred; industry contributions resulting from mine and manufacturers visits; and the evaluation of the preliminary guidelines by three operating mines. This report describes the basic aspects of tire and rim selection and use. Tire users are provided with a tire evaluation program that can contribute to improved safety and better tire application. Statistical accident data, accident reports, and a bibliography are included to emphasize the mining industry's contribution and concern with tire operation and safety. Research done under contract J0285004 by International Mining Consultants, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–194532; paper copy price code A07.

OFR 45–81. Criteria for Determining When a Body of Surface Water Constitutes a Hazard to Mining, by F. S. Kendorski, I. Khosla, and M. M. Singh. Aug. 31, 1979. 363 pp. 101 figs. This report covers the work on developing criteria for determining when a hazard exists when mining stratified mineral deposits beneath bodies of surface water. The nature of water bodies is considered, the disturbance to the strata induced by mining is described, inundation case histories reviewed, reasonable water inflows derived, and methods of mining to prevent or minimize the hazard are presented. Criteria are given whereby affected industries and agencies can recognize a potential hazard and plan a mine accordingly, releasing considerable mineral reserves otherwise considered unminable. Research done under Contract No. J0285011 by Engineers International, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–194938; paper copy price code A16.

OFR 46(1)–81. Risk Analysis for Rock Slopes in Open Pit Mines. Part I. Distribution of Rock Mass Properties, by Herbert H. Einstein, Gregory B. Baecher, Daniele Veneziano, Hing C. Chan, William S. Dershowitz, Edward F. Glynn, Jean Luc Galzi, Nicholas A. Lanney, Kevin O'Reilly, William S. Scull, and Peter Yip. November 1979. 200 pp. 85 figs. The objective of this research was to collect in situ data from exploration programs and published literature, and to empirically establish distributional patterns for these variables. Since discontinuities in a rock mass govern its engineering properties to a large extent and thus the performance of any slope in the mass, work has been devoted to determining the appropriate distributional forms for attitude, spacing and length of discontinuities, and to distributional properties of resistance and deformability parameters. The conclusion from these analyses is that trace lengths are log-normally distributed and that joint spacing is exponentially distributed, regardless of orientation of the sampling line, and regardless of whether each joint set is considered separately or not. Research done under contract J0275015 by Massachusetts Institute of Technology. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va., National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Wash-

ington, D.C. Order ONLY from NTIS: PB 81–201592: paper copy price code A09.

OFR 46(2)–81. Risk Analysis for Rock Slopes in Open Pit Mines. Part II. Limit Equilibrium Analysis for Rock Wedge Stability, by Herbert H. Einstein, Gregory B. Baecher, Daniele Veneziano, Hing C. Chan, William S. Dershowitz, Edward F. Glynn, Jean Luc Galzi, Nicholas A. Lanney, Kevin O'Reilly, William S. Scull, and Peter Yip. November 1979. 182 pp. 78 figs. Instability of rock slopes often occurs in the form of excessive movement of bodies that are bounded by discontinuities. The well-known limit equilibrium analysis for wedges and blocks suffer from procedural simplifications and from the basic deficiency of limit equilibrium analysis—the rigid body assumption. Thus, stability analysis for two- and three-plane wedges with a wide range of additional features regarding failure mode and external forces have been developed. The deficiency, due to the rigid body assumption, was corrected by an approach that includes the effects of the in situ stress field and of the stiffness of discontinuities. The final step in making limit equilibrium approaches more valid was achieved with artificial supports which makes it possible to identify the most critical failure mode and to determine the corresponding factor to safety. The analytical development includes the creation of appropriate computer codes and routines for programmable pocket calculators. Research done under contract J0275015 by Massachusetts Institute of Technology. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo, Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–201600; paper copy price code A09.

OFR 46(3)–81. Risk Analysis for Rock Slopes in Open Pit Mines. Part III. Reliability Analysis of Rock Slope Stability, by Herbert H. Einstein, Gregory B. Baecher, Daniele Veneziano, Hing C. Chan, William S. Dershowitz, Edward F. Glynn, Jean Luc Galzi, Nicholas A. Lanney, Kevin O'Reilly, William S. Scull, and Peter Yip. November 1979. 354 pp. 162 figs. The innate variability of natural materials and processes causes uncertainty in the models representing the natural phenomena and uncertainty in estimating the parameters that are used. Reliability analyses are well-suited to a rational incorporation of uncertainty in design and exploration decisions. Probabilistic kinetic and kinematic analyses were developed and combined to form reliability analysis methods. With one method the reliability (the probability of failure) of an individual two-plane wedge in a slope can be determined. The other method is aimed at slopes with a single-slope parallel set of joints. In each case two approaches were developed, an encompassing one relying on computer codes and a simplified approach relying on charts or pocket calculator computation. A major contribution of these approaches is the treatment of joint persistance. Instead of having to assume a certain persistance, it is now possible to use exploration data on joint geometry and to include the persistence effect rigorously. Research done under contract J0275015 by Massachusetts Institute of Technology. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–201618; paper copy price code A16.

OFR 46(4)–81. Risk Analysis for Rock Slopes in Open Pit Mines. Part IV. Field Exploration To Determine Rock Mass Properties, by Herbert H. Einstein, Gregory B. Baecher, Daniele Veneziano, Hing C. Chan, William S. Dershowitz, Edward F. Glynn, Jean Luc Galzi, Nicholas A. Lanney, Kevin O'Reilly, William S. Scull, and Peter Yip. November 1979. 176 pp. 85 figs. Sampling plans and methods of statistical inference for rock mass properties are developed aimed at overcoming statistical biases in drawing inferences from joint survey data. The approach to exploration strategy analysis (optimization) is through the "expected value of information" (EVI) of decision theory and two cases are analyzed: the one-joint set (parallel to slope) case and the general shear case. In conjunction with the analysis of optimal exploration strategies for single slopes, a graphical risk screening procedure was developed to determine those slope sections within a pit for which increased exploration would beneficially reduce risk. Research done under contract J0275015 by Massachusetts Institute of Technology. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va., National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–201626; paper copy price code A09.

OFR 46(5)–81. Risk Analysis for Rock Slopes in Open Pit Mines. Part V. Probablistic Models of Jointed Rock Mass Deformation and Their Implications, by Herbert H. Einstein, Gregory B. Baecher, Daniele Veneziano, Hing C. Chan, William S. Dershowitz, Edward F. Glynn, Jean Luc Galzi, Nicholas A. Lanney, Kevin O'Reilly, William S. Scull, and Peter Yip. November 1979. 113 pp. 49 figs. Rock mass deformability is commonly predicted using correlations with RQD or other indices of rock mass quality or by extrapolation from large in situ tests. Based on the probabilistic description of rock masses empirically developed, a new approach was attempted in modeling for predictions of deformability. This approach decomposes the rock mass into spatially variable joints described by probability distributions and intact rock blocks. Stiffnesses and elastic parameters are associated with the joints and intact blocks and deformations are built up by adding the contributions of each. This allows relaxation of many of the simplistic geometric assumptions that constrain parallel attempts to model deformation in rock masses. The model has been applied to four standard cases to test its results against previously existing models and to check whether it replicates

empirical correlations. When joints are taken as parallel, common empirical correlations are closely approximated by the model output. However, the closeness to empirical correlation breaks down when variability of the jointing geometry is increased. Research done under contract J0275015 by Massachusetts Institute of Technology. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–201634; paper copy price code A06.

OFR 46(6)–81. Risk Analysis for Rock Slopes in Open Pit Mines. Part VI. Executive Summary, Introduction and Technical Summary, Bibliography, by Herbert H. Einstein, Gregory B. Baecher, Daniele Veneziano, Hing C. Chan, William S. Dershowitz, Edward F. Glynn, Jean Luc Galzi, Nicholas A. Lanney, Kevin O'Reilly, William S. Scull, and Peter Yip. November 1979. 63 pp. The purpose of this report is to provide a summary overview of the research goals and results of this investigation in an executive summary followed by a detailed introduction to the research and a comprehensive summary of the work performed. The structure of the summary reflects that of the entire report, devoting a section to each part and subdividing each section into paragraphs corresponding to the chapters in the particular part. Although there is a systematic relation between chapters and parts, the report is written such that each chapter can be used individually, providing a method or reporting results that can be practically applied. Research done under contract J0275015 by Massachusetts Institute of Technology. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash., U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–201642; paper copy price code A04.

OFR 46(7)–81. Risk Analysis for Rock Slopes in Open Pit Mines. Part VII. Appendices A Through M, Detailed Geologic Data Underlying Developments, by Herbert H. Einstein, Gregory B. Baecher, Daniele Veneziano, Hing C. Chan, William S. Dershowitz, Edward F. Glynn, Jean Luc Galzi, Nicholas A. Lanney, Kevin O'Reilly, William S. Scull, and Peter Yip. November 1979. 394 pp. 144 figs. Appendices A through M of this eight-volume report contain information that is the basis for many developments reported in the main text. The information is, however, not needed in applying the research results. Research done under contract J0275015 by Massachusetts Institute of Technology. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–201659; paper copy price code A18.

OFR 46(8)–81. Risk Analysis for Rock Slopes in Open Pit Mines. Part VIII. Appendix UM, User's Manuals for Computer Programs, by Herbert H. Einstein, Gregory B. Baecher, Daniele Veneziano, Hing C. Chan, William S. Dershowitz, Edward F. Glynn, Jean Luc Galzi, Nicholas A. Lanney, Kevin O'Reilly, William S. Scull, and Peter Yip. November 1979. 453 pp. 40 figs. This report contains the documentation for 11 computer programs representing the entire computer documentation for the eight-volume report entitled "Risk Analysis for Rock Slopes in Open Pit Mines." A detailed summary of the programs is included. Research done under contract J0275015 by Massachusetts Institute of Technology. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–201667: paper copy price code A20.

OFR 47–81. Geotechnical Properties of Oil Shale Retorted by the Paraho and Tosco Processes, by Frank C. Townsend and Richard W. Peterson. November 1979. 271 pp. 77 figs. The objective of this investigation was to determine the physical and geotechnical properties and composition of spent oil shale by the Paraho and Tosco processes. The program was divided into three categories: physical properties, engineering properties, and compositional and durability characteristics. The physical properties tests consisted of typical classification tests for identifying and comparing the retorted shales with other materials. The engineering characterization investigated compaction, consolidation, shear strength, self-cementing tendencies, particle breakage and abrasion, dynamic properties, and earthquake resistance. Compositional tests consisted of X-ray diffraction, petrographic and scanning electron microscopy, and differential thermal and chemical analyses. Research done under Contract No. H0262064 by U.S. Army Engineer Waterways Experiment Station. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: ADA-082317; paper price code A12.

OFR 48–81. Electromagnetic Retransmission System for Locating Trapped Mine Workers, by Frederick H. Raab and Per Krogh Hansen. February 1980. 268 pp. 71 figs. The electromagnetic retransmission system is a new, automated method of locating trapped mine workers. This technique overcomes many limitations inherent in electromagnetic direc-

tion finding by reducing the effects of the conducting ground to an acceptable maximum, by finding position accurately in the presence of antenna tilt, and by eliminating the need for the receiver to be located directly above the subsurface transmitter. Three transportable three-axis magnetic-dipole transmitters on the surface create a system of electronic grids in which the phases of the downlink signals convey position information. The subsurface retransmitter modulates the uplink carrier of the existing beacon transmitter with the received downlink signal; the coal-pillar loop antenna is used for both receiving and transmitting. The uplink receiver uses a three-axis antenna and extensive digital signal processing. A small computer integrates data, estimates position, and controls system operation through VHF-FM communications. Both coal-mine and deep-mine operations are possible by selecting appropriate transmitting power and signal frequencies. Research done under contract H0188071 by Polhemus Navigation Sciences, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-215329; paper copy price code A12.

OFR 49–81. Improved Hardware for Trolley Wire Phone Systems, by Joseph L. Harley, Jr. March 1979. 55 pp. 17 figs. This report presents the investigation and engineering of state-of-the-art trolley wire phone hardware. The various problem areas of trolley wire communication systems are discussed with the objective of improving circuit performance to compensate for the poor transmission characteristics of the line. Relatively inexpensive hardware designed for this purpose is detailed and documented. Research done under contract H0166144 by GAI-Tronics Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-214363; paper copy price code A04.

OFR 50–81. Borehole Mining: An Environmentally Compatible Method for Mining Oil Sands, by G. S. Knoke and W. R. Archibald. February 1980. 114 pp. 32 figs. This report presents the results of a demonstration of the technical, economic, and environmental feasibility of hydraulic borehole mining of shallow oil sands. Borehole mining offers a method for extracting the oil sands with minimal disturbance to environmental quality. This project consisted of two concurrent tasks: mining operations and environmental monitoring. To generate the environmental impact, nearly 1,000 tons of oil sands were mined from two boreholes. Water quality and ground subsidence were monitored. No significant changes occurred in the chemical composition of the process water, indicating that the borehole mining process does not dissolve the mined material. The average subsidence in the immediate vicinity of the boreholes was about ½ inch, although some points were slightly elevated. In general, the amount of subsidence increased with time and decreased with distance from the borehole. A mining cost analysis was used to project an estimated cost for production mining of about $38 per barrel of oil. Research done under contract J0295064 by Flow Industries, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-214231; paper copy price code A06.

OFR 51–81. Preconditioning an Entire Stope Block for Rock Burst Control, by Wilson Blake. May 1980. 32 pp. 15 figs. Rock preconditioning in advance of mining has been an effective means of rock-burst control based on small-scale field demonstrations. The objective of this investigation was to test the effectiveness of rock preconditioning on a larger scale and to determine whether the preconditioning would be effective over a specific period of time. Preconditioning in 8 and 12 crosscuts on the 7900 level of the Hecla Mining Co.'s Star Mine involved about 7,232 feet of drilling and the blasting of about 10,055 pounds of high explosives to precondition a block of ground along the main vein of about 450 feet long, 50 feet above, and 40 feet below the level. The slight amount of seismic energy accompanying the initial raiseup in the preconditioned stopes indicates that this preconditioning was successful. Continued monitoring should be carried out to determine whether the preconditioning remains effective over the length of time required for the completion of mining in a stope block. Research done under contract J0295080. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-214983; paper copy price code A03.

OFR 52–81. Wallrock Reactions to Mining Beyond a Preconditioned Zone at the Star Mine, Burke, Idaho, by Wilson Blake. April 1980. 45 pp. Rock preconditioning in advance of mining has been an effective means of rock-burst control based on the results of field demonstrations carried out on the 7700 level of the Hecla Mining Co.'s Star Mine. Mining through the preconditioned zone was characterized by greatly reduced rates of released seismic energy and no bumping or rock bursting occurred within the preconditioned zone. Mining above the preconditioned zone was characterized by greatly increased rates of released seismic energy and rock bursting, particularly where the vein became very

narrow in waste zones. This increased incidence of rock bursting points out the need for stope preconditioning to be carried out on an entire stope block basis. Research done under contract H0262039. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va., National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-214355; paper copy price code A03.

OFR 53-81. Survey of Attractive Energy Storage and Power Averaging Concepts Applicable to Mining Machines, by William N. Patterson, Leslie Travis, and Lawrence Owens. July 31, 1980. 154 pp. 15 figs. Drive systems for mining machines are usually sized to accommodate anticipated peak loads. Usually, the average power requirements are considerably less. Energy storage and power averaging are attractive concepts for mining machinery and could have far-reaching implications. The purpose of this program was to identify truly feasible concepts; identify advantages and/or disadvantages, limitations, and constraints; evaluate feasibility based on today's technology; identify anticipated safety problems; and provide the designer with a comprehensive literature base. Concepts evaluated include flywheels, high energy batteries, gas-charged accumulators, inductive storage, capacitive storage, springs and counterweights, thermal, closed cycles, internal combustion engines, and trolley and hybrid systems. A comprehensive index is provided, and an appendix is included containing abstracts of pertinent literature. Research done under contract J0285041 by Woodward Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-217002; paper copy price code A08.

OFR 54-81. Improving Surface Coal Refuse Disposal Site Inspections, by R. A. Meister and R. L. Hoffman. September 1980. 297 pp. 169 figs. The study on improving surface coal refuse disposal site inspections included surface inspections of 15 refuse disposal sites. Monthly aerial photos were taken of the sites and computer methods were used to determine elevation changes. Photogrammetric techniques that were used are described in detail. A comparison of the results of each of these inspection techniques is included. A detailed evaluation of the photogrammetric techniques was made and conclusions were drawn concerning the advantages and disadvantages of using aerial photography and photogrammetry as part of the inspection procedure. Operators' opinions of the aerial photography methods are included. Research done under contract J0188027 by Chicago Aerial Survey. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-215402; paper copy price code A13.

OFR 55-81. Detection of Coal Mine Workings Using High-Resolution Earth Resistivity Techniques, by Wendell R. Peters, Thomas M. Campbell, and Vernon R. Sturdivant. Sept. 26, 1980. 80 pp. 25 figs. Shallow underground voids resulting from early coal mining and other resource recovery activities over the past several decades are now being recognized as a significant cause of ground subsidence problems in developing urban areas. Uncertain knowledge of abandoned coal mines also imposes potential hazards in coal excavation operations since water inundation or the release of methane gas is a principal hazard when mine excavation operations break into an abandoned mine. U.S. Army requirements for an effective method for detecting and mapping subversive abandoned tunnels have resulted in a surface-operated automatic earth resistivity survey system with a digital computer data processing system. Field tests aimed at demonstrating the system performance resulted in successful detection of tunnels having depth-to-diameter ratios up to 15 to 1. Under the sponsorship of the Bureau of Mines, a similar system was designed and constructed for use in the detection of coal mine workings. This report discusses the hardware and software aspects of the system and the application of the high-resolution earth resistivity method to the survey and mapping of abandoned coal mine workings. In the field tests reported, the targets of interest were both air- and water-filled workings. Research done under contract H0292030 by Southwest Research Institute. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va., National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-215378; paper copy price code A06.

OFR 56-81. Feasibility Analysis of Implementing Rail Car Brakes in Underground Coal Mines, by Charles G. Howard, Bruce H. W. Pinkston, and Fujio Hayashi. Oct. 1, 1979. 119 pp. 25 figs. Accidents involving underground rail transport were analyzed to quantify the magnitude and operational requirements for individual mine car braking systems. The results showed that the brake preventable accidents represent only 2 pct of the total underground fatal accidents and less than 1 pct of the total underground nonfatal accidents. In addition, brake preventable accidents are expected to decline over the next decade. The costs of accidents involving deaths and injuries were determined using various well-accepted methods. The costs of a brake retrofit program for all operating underground coal cars were developed separately for small and large coal mines. Costs of retrofit brakes, new car brakes,

maintenance, inspection, and repair facilities were included in the estimates. The analysis showed that a retrofit program would not significantly increase safety, and that the program cost would greatly exceed the corresponding expected benefits. Research done under contract J0188085 by Booz, Allen & Hamilton Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-215360; paper copy price code A06.

OFR 57–81. Dust Collector on Longwall Shearer, by Dennis J. Grigal. February 1980. 81 pp. 36 figs. The goal of this program is to develop a dust collector system mounted on a ranging drum or arm shearer that will reduce the respirable dust level of the shearer operator by at least 75 pct, be easily and economically mounted on an existing shearer, and will not, through modifications to the shearer, reduce its safety or productive capability. The development program consists of three phases covering the activities of the design of the dust collector system, fabricating and installing it on the ranging arm or drum shearer, and conducting underground field tests on the modified mining machine. Research done under contract H0242012 by Donaldson Co., Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-214926; paper copy price code A05.

OFR 58–81. Electrochemical Gas Sensors for Mine Atmospheres: Portable Detectors for Carbon Monoxide and for Nitric Oxide/Nitrogen Dioxide Mixtures, by John Kosek and Stanley Bruckenstein. February 1979. 212 pp. 31 figs. A portable detector for mixtures of nitric oxide and nitrogen dioxide was developed using a porous silver cathode in sulfuric acid supporting electrolyte. Nitrogen dioxide was determined in the gas stream by electroreduction. The nitric oxide in the gas stream was oxidized to nitrogen dioxide by passing it over Cr (VI) on firebrick. Electroreduction gave the sum of NO + NO_2. Analog circuitry was used to display the amounts of NO and NO_2 separately. Two ranges available for each gas were, in parts per million, 0 to 10 and 0 to 50 for NO, and 0 to 2 and 0 to 10 for NO_2. Research done under grant G0155007 by State University of New York at Buffalo. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va., National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-214934; paper copy price code A10.

OFR 59–81. Considerations for the Certification of Blasters, by John R. Coulson and Larry T. Southall, II. February 1980. 79 pp. The objective of this report was to determine the existing Federal and State requirements for blasters working on the surface or underground in metal, nonmetal, and coal mine operations; determine industry needs for blasting personnel and recommend licensing requirements for blasters; determine the types of training now available and compare the training needs with the training available; and consolidate the above and make recommendations. The Federal Government and each State were surveyed for existing certification requirements and the industry was surveyed for the needs for training blasters and for available training. Recommendations for training and certification for blasters are made. Research done under contract J0285012 by E. I. du Pont de Nemours & Co., Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-214116; paper copy price code A05.

OFR 60–81. An Investigation of the Mechanics and Noise Associated With Coal Cutting, by Robert S. Becker and Granville R. Anderson II. Feb. 15, 1980. 275 pp. 171 figs. The results of a laboratory investigation of coal cutting mechanics and noise are presented. The 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 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. Research done under contract J0177060 by Wyle Laboratories. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-215394; paper copy price code A12.

OFR 61–81. The Impact of Eliminating Safety Fuse From Metal/Nonmetal Mines, by Dipak Sengupta, Gordon French, Mir Heydari, and Kanaan Hanna. August 1980. 211 pp. 25 figs. This study analyzes the safety, technology, and economic impact of eliminating safety fuse from metal and nonmetal mines based on operation and manufacturer experience over the past 5 to 10 years. If safety fuse is eliminated, blasting accide ts will decrease with no

technical impact except for some limited, specific applications. The economic impact will be minor for large operations, but will be significant enough that some small operations will likely close rather than change. The majority of the mines would probably change over, with the extra cost absorbed by the market. Elimination of safety fuse would have obvious impact on the two manufacturers of safety fuse; one manufacturer already produces an alternative system, and will remain unaffected. The other manufacturer will be affected if they do not change their production strategy. There will be a very minor effect on the mining industry as a whole due to abolishment of safety fuse from the standpoint of employment or production. Research done under contract J0295010 by Science Applications, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–215386; paper copy price code A10.

OFR 62–81. Direct Calcination of $AlCl_3.6H_2O$ With Off-Gas Use for Crystallization, by L. Keith Hudson and Jamie K. Carnevale. Jan. 12, 1979. 30 pp. 5 figs. This report describes the results of a study to provide data that would demonstrate the decomposition of aluminum chloride hexahydrate using the Alcoa flash calciner design, and to show that hydrogen chloride in the off-gas from the calciner could be absorbed into process solutions to effect crystallization of aluminum chloride hexahydrate. Research done under contract J0188096 by Aluminum Co. of America. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va., National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–214827; paper copy price code A03.

OFR 63–81. Investigation of the Formation of Vapor Complexes Between Alumina Chloride and Impurity Elements Associated With Aluminum Raw Materials, by John P. Hager and Harry S. Patsos. Dec. 22, 1980. 79 pp. 3 figs. This study investigated the formation of vapor complexes between aluminum chloride and the chlorides of iron, titanium, and silicon. For the Al-Fe-Cl system the proposed gaseous complex species is $Al_2Fe_2Cl_{12(g)}$. In the Al-Ti-Cl and Al-Si-Cl systems the proposed vapor complex species are $Al_2Ti_2Cl_{14(g)}$ and $Al_2Ti_2Cl_{14(g)}$, respectively. Free energy expressions were estimated for the formation of the two complex species. Research done under contract J0199151 by Colorado School of Mines. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–214850; paper copy price code A05.

OFR 64–81. Evaluation, Modification & Application of Roadheaders in Underground Uranium Mines, by J. P. Connell, C. M. Gibbs, C. L. Livesay, D. C. Myntti. and J. M. Taipale. September 1980. 73 pp. 17 figs. This study evaluates the use of roadheaders in underground mining operations. The report identifies roadheader operating problems and offers suggestions for improved mechanical and electrical design along with manufacturer and owner responsibilities for improved availability. The development of a complex integrated excavation and ground support system is not warranted until the roadheader itself is made much more reliable. Research done under contract H0282024 by Morrison-Knudsen Co., Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va., National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–214835; paper copy price code A04.

OFR 65–81. Calcia Stabilized Zirconia Castable, by J. Benzel, J. Cochran, R. Kolarik, K. Lee, E. McGee, and L. Smith. June 1980. 112 pp. 29 figs. This report presents the results of research on castable refractories made from calcium aluminate and zirconia suitable for use in high-temperature furnaces. The results indicated that reductions in the amounts of zirconia compared with conventional materials were possible with resultant materials and energy cost savings. The new formulations were demonstrated in producing refractory kiln furniture. Research done under grant G0177145 by Georgia Institute of Technology. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–214819; paper copy price code A06.

OFR 66–81. Innovative Technology for Fabrication of Ceramics: EDS Rapid Solidification Process Application to Specialized Materials, by Della M. Roy, Rustum Roy, and T. P. O'Holleran. Nov. 15, 1980. 52 pp. 8 figs. This report presents results of innovative research on a novel rapid solidification technology method to produce fine ceramic powders of many compositions with unique properties. The process uses salt solutions and includes two steps, the first to evaporate the liquid and the second to very rapidly decompose the salt to a very fine powder. The process has been demonstrated in terms of the following material applications: aluminates, ferrites, phosphors, ionic conductors, and cements. This new tech-

nique of producing ceramic powders offers a number of potential advantages over existing methods such as ability to produce complex compositions, lower energy requirements, and improved properties. Research done under grant G0155191 by Pennsylvania State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va., National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-214868; paper copy price code A04.

OFR 67-81. Coupled Transport Membranes for Metal Separations. Final Report, Phase IV, by W. C. Babcock, R. W. Baker, D. J. Kelly, E. D. LaChapelle, and H. K. Lonsdale. August 1979. 97 pp. 47 figs. This report presents the results of continuing innovative technology research to use coupled transport membranes to separate metals in solution, namely vanadium and uranium. The development of new hollow fiber membranes is described. Bench-scale tests demonstrated the clean separation of uranium from vanadium and iron. Future work will involve testing the membranes under actual field conditions. Research done under contract H0282023 by Bend Research, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-214843; paper copy price code A05.

OFR 68(1)-81. An Annotated Bibliography of Metal and Nonmetal Mine Fire Reports. Final Report, Volume I, by Robert M. Baker, John Nagy, L. Bruce McDonald, and James Wishmyer. Dec. 5, 1980. 64 pp. The objectives of this three-volume report were to develop an annotated bibliography that included MSHA accident reports and periodicals, to gather data on nonreportable fires, and to conduct statistical analyses on the data to delineate trends for the period 1950-79. The data were acquired from periodicals, MSHA fire reports, and mine safety directors. Volume I contains data on acquisition and analysis procedures, conclusions, and recommendations. Research done under contract J0295035 by Allen Corp. of America. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-223729; paper copy price code A04.

OFR 68(2)-81. An Annotated Bibliography of Metal and Nonmetal Mine Fire Reports. Volume II, by Robert M. Baker, John Nagy, L. Bruce McDonald, and James Wishmyer. Dec. 5, 1980. 284 pp. The objectives of this three-volume report were to develop an annotated bibliography that included MSHA accident reports and periodicals, to gather data on nonreportable fires, and to conduct statistical analyses on the data to delineate trends for the period 1950-79. The data were acquired from periodicals, MSHA fire reports, and mine safety directors. Volume II contains a chronological list of mine fires and 15 indexes to assist in locating fire incident reports of interest. Research done under contract J0295035 by Allen Corp. of America. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-223737; paper copy price code A13.

OFR 68(3)-81. An Annotated Bibliography of Metal and Nonmetal Mine Fire Reports. Final Report, Appendix, by Robert M. Baker, John Nagy, L. Bruce McDonald, and James Wishmyer. Dec. 5, 1980. 390 pp. The objectives of this three-volume report were to develop an annotated bibliography that included MSHA accident reports and periodicals, to gather data on nonreportable fires, and to conduct statistical analyses on the data to delineate trends for the period 1950-79. The data were acquired from periodicals, MSHA fire reports, and mine safety directors. The appendix contains the annotated bibliography of over 300 metal and nonmetal mine fire reports, journal articles, and a list of nonreportable fires. Research done under contract J0295035 by Allen Corp. of America. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-223745; paper copy price code A17.

OFR 69-81. Trona Occurrences Within the Yukon Flats Basin, Alaska, by Karen H. Clautice and Thomas C. Mowatt. 1981. 34 pp. 5 figs. Fieldwork conducted by the Bureau of Mines as part of the mineral resource evaluation program of the Yukon-Tanana uplands and vicinity has delineated a northeasterly trend of evaporite deposits within the Yukon Flats Basin. The deposits occur locally as efflorescent salt films less than 1 cm deep about lake margins and dry lake beds within an area of approximately 240 km. The evaporites are precipitated from turbid lakes, which are in contrast with clear lakes elsewhere in the Flats. The mineral trona has been identified by X-ray diffraction techniques in major amounts in the evaporites from numerous locations. Calcite and/or dolomite are ubiquitous associates. Trona has also been identified in minor amounts within some lake sediments to a depth of 76 cm. X-ray emission spectrometric analysis has shown sodium to be the dominant element in all samples in the water soluble extract. Research done by Alaska Field Operations Center. Available for

reference at the Office of the Director, Division of Mineral Land Assessment, Bureau of Mines, Washington, D.C.; Bureau of Mines facilities in Anchorage, Fairbanks, and Juneau, Alaska; 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 70–81. Evaluation of the Environmental Factors Involved in Metallurgical Processes To Utilize Domestic Resources for Production of Alumina. Environmental Aspects of Preliminary Pilot-Plant Design, by T. Bertke, D. Loudin, and D. Armentrout. December 1980. 48 pp. 4 figs. This report assesses the environmental aspects of a preliminary design for processing kaolin clay as the domestic resource for recovery of alumina by a hydrochloric acid leach-HCl gas-induced crystalization process. The report covers waste sources, control measures, and potential environmental and health effects applicable to the process technology. Research done under contract J0275047 by PEDCo Environmental, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–225906; paper copy price code A03.

OFR 71–81. Application of Weathering Protection at the Face, by David C. McHuron. Aug. 19, 1980. 50 pp. 13 figs. Many underground coal mines are composed of shale layered directly over the coal that weathers severely immediately after exposure to the mine atmosphere. Condensation of ventilating air causes underground coal mines to become wet during warm months; during cool months, the mines become dry from evaporation. The fluctuating mine atmosphere is responsible for the severe shale break-up experienced during the summer and lessening of the break-up through the winter months. The objective of this investigation was to design and construct spray equipment to be mounted on a continuous miner for sealing the mine roof immediately after exposure. Selection of the sealant and a field evaluation of the equipment is included. Research done under contract H0272008 by MBAssociates. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-223380; paper copy price code A03.

OFR 72–81. The Input-Output Structure of the U.S. Mineral Industries for 1967 With RAS Updates to 1972 and 1977, by Everard M. Lofting, H. Craig Davis, and Werner O. Schink. February 1980. 47 pp. This report presents the detailed U.S. mineral interindustry transactions table for 1967 showing the 47 mineral subindustries along with the RAS updated tables for 1972 and 1977. The principal features of the updating technique and the data and procedures used are discussed. The output multipliers and types I and II income and employment multipliers are calculated and presented comparatively for each of the interindustry tables. Research done under grant G0155111 by Dry Lands Research Institute. Available for reference at Bureau of Mines facilities in Juneau, Alaska, Denver, Colo., Pittsburgh, Pa., and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–225898; paper copy price code A03.

OFR 73–81. Evaluation of Lixiviation of Mine Wastes, by K. L. Bainbridge, M. A. Wilkinson, and B. M. Mahar. December 1980. 239 pp. 12 figs. This report describes the results of a study to determine which types of, and to what extent, mining wastes can contaminate ground water through leaching of acid-forming or potentially toxic constituents. The primary focus of this study was on coal mining wastes, especially overburden spoils and preparation plant refuse. In addition, the potential for contamination by leachates from clean coal stockpiles was also examined. The study approach included investigation of the amounts and geographic locations of mining wastes in the United States; the chemical character of mining wastes, especially with regard to potentially acid-forming or toxic constituents; and the extent to which acid and/or toxic components are leached from mining wastes by rainwater. To evaluate the leachability of coal wastes, a laboratory waste-leaching method was developed to specifically simulate the leaching process over a long term. Waste samples were also leached by the EPA extraction procedure and ASTM waste leaching method. Results of the three leach-test methods were compared to evaluate their relative capabilities to predict the leachability of mining wastes. Research done under contract J0199057 by Calspan Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–222515; paper copy price code A11.

OFR 74–81. A Study of the Behavior of Underground Openings During Block Caving Operations, by Giovanni Barla and Stefon H. Boshkov. June 1979. 400 pp. 250 figs. This report describes studies of the influence of block-caving operations on underground openings, and attempts to correlate observed behavior with mathematical models developed to explain this behavior. The studies proceeded by obtaining in situ stress measurements and attempting to relate the measured stress to field conditions by finite element modeling. A principal objective was to develop the capability to predict ground movement based upon stress measurement and an appropriate model; however, predictive capability is strongly influenced by the proper choice of rock strength properties used in the model. Some conclusions in the report, particularly those relating to stress distribution in supports, are potentially useful to mine designers. For example, a delay in support installation and better control of undercutting could be beneficial during mining by the block-caving method. Research done under contract J0275005 by H. Krumb School of Mines. Available

for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; 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 75–81. The Electrochemical Characterization of Metallic Calcium, Strontium, and Barium Electrodes, by Robert T. Foley and W. Timothy Adams. Sept. 30, 1980. 13 pp. The objective of this study was to evaluate the feasibility and economic potential of using the alkaline earth metals, calcium, strontium, and barium, in electrochemical cells. After searching the literature for reported research, and considering well-known properties of these metals, it was concluded that the metals are attractive for electrode uses based upon their physical and chemical properties, but not attractive from electrochemical considerations. Both aqueous and nonaqueous electrolytes were evaluated in the study. Research done under contract J0199022 by American University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; 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 76–81. Data Security for In-Mine Transmission. Final Report—Part I, by Jon G. Bredeson, Jeffery L. Kohler, and Harvinder Singh. February 1981. 111 pp. 33 figs. The electromagnetic noise that exists in a mining environment is quite severe and has been reasonably well-documented by a number of resarchers. The noise level is such that prudent communication design requires the careful use of all the electromagnetic noise data available. A comprehensive survey was undertaken to determine techniques used in various industrial environments to achieve secure communications in the presence of electromagnetic interference. Several communication systems intended for use in a mining environment were examined, and the bit error rate as a function of distance was mathematically determined and plotted. The data communication protocol for these communication systems was examined and the probability of an undetected error versus distance was mathematically determined and plotted. The burst error detection capabilities are analyzed and presented. Conclusions and recommendations are presented for different communication systems, and significant mathematical developments and background information is included in the appendices. Research done under contract J0308024 by University of Oklahoma. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va., National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–221988; paper copy price code A06.

OFR 77–81. A Model for the Determination of Flyrock Range as a Function of Shot Conditions, by Julius Roth. Apr. 16, 1979. 97 pp. 19 figs. Flyrock is the source of most of the injuries and property damage in a majority of blasting accidents in surface mines. A quantitative correlation between shot conditions and maximum flyrock range can be used to define a blasting area in which no personnel or equipment should be present during a shot. The approach used was to develop a model that correlates shot conditions and initial flyrock velocities and permits computation of flyrock range from ballistic trajectories. The Gurney formula for velocity of explosively propelled plates or fragments was adapted to explosively propelled flyrock from vertical rock faces or from bench tops. The modified Gurney formula was then calibrated with measured flyrock velocities from mining and explosives literature. Charts were then developed for possible field use that gives maximum flyrock range as a function of shot conditions. Research done under contract J0387242 by Management Science Associates. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–222358; paper copy price code A05.

OFR 78–81. Development of a Visual Display and Control System, by Arthur D. Little, Inc. October 1980. 31 pp. 6 figs. The object of this program was to extend the capabilities of visual paging systems both in size and functions in mines. The system developed uses the mine pager phone line for communication, monitoring, and remote control. A central station, using a minicomputer, transmits signals by phase inversion modulation of a 16,384-Hz carrier to as many as 999 remote units. The remote unit addressed returns an echo to indicate that it is functioning and, in the case of monitor units, to convey the monitor data. Magnetically latched display disks, which can be seen from both sides when posted, are used for visual paging. Lists of the addresses of posted pages, unanswered pages, and nonechoing units are prepared by the central station computer. The system was designed to be intrinsically safe and should operate for 3 months on a 12-volt lantern battery. Research done under contract J0177020. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of the Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–222374; paper copy price code A03.

OFR 79–81. Coal Mine Hazard Detection Using Synthetic Pulse Radar, by James C. Fowler, Steven D. Hale, and Richard T. Houck. January 1981. 86 pp. 55 figs. The purpose of this project was to prove the feasibility of detecting hazards in a coal seam using a synthetic pulse radar. The work was conducted in three phases. The first was an analysis of the type of errors that might cause problems, the second was to build a breadboard radar, and the third was to conduct a field test with the system. The work from each phase is discussed and the results of the field test are presented. The results show propagation of the radar signal through 200 feet of coal along with reflections from 50 feet away. The final section contains recommendations for future development. Research done under contract H0292025 by ENSCO, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–224412; paper copy price code A05.

OFR 80(1)–81. Selective Interburden Handling Techniques. Volume I—Summary, by Robert L. Lappi and George M. Smrikarov. September 1980. 125 pp. 21 figs. Eight interburden handling concepts are developed for multiple seam area mine stripping operations in central and western United States. They are based on data gathered and analyzed during field surveys, literature reviews, and visits to State regulatory agencies in five States. It is concluded that improvement of reclamation practices through selective interburden handling techniques is possible at lower operating costs than currently incurred. Specific multiple seam mining systems are discussed in this report. Research done under contract J0285025 by Mathtech, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–221905; paper copy price code A16.

OFR 80(2)–81. Selective Interburden Handling Techniques. Volume II—Appendices, by Robert L. Lappi and George M. Smrikarov. September 1980. 321 pp. 44 figs. A summary of the major findings of the literature survey for interburden handling concepts are presented. Literature pertaining to mine practices in multiseam strip mining operations were reviewed. The survey covered two coal regions: the Western coal region with emphasis on the Northern Great Plains coal province and the Interior Central coal region with emphasis on the tri-State area of Illinois, Indiana, and west Kentucky. Previous works on multiseam mining and selective handling techniques were identified and evaluated. The effects of the current proposed State and Federal surface mining laws on alternative interburden handling techniques employed in the Western and Central coal regions are discussed. Research done under contract J0285025 by Mathtech, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–221913; paper copy price code A14.

OFR 81(1)–81. Precalculation of the Effect of Fires on Ventilation Systems of Mines. Volume I, by Rudolf E. Greuer. June 27, 1979. 85 pp. This report contains the practical application of a computer program for the simulation of ventilation systems under the influence of mine fires and other emergencies on five hardrock mines. For each of the selected mines, the ventilation system, the source of the used ventilation data, and the preparation for computer simulations are outlined. Volume I describes the program. Research done under contract J0285002 by Michigan Technological University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; 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 81(2)–81. Precalculation of the Effect of Fires on Ventilation Systems of Mines. Volume II, Figures and Tables, by Rudolf E. Greuer. June 27, 1979. 182 pp. 45 figs. This report contains the practical application of a computer program for the simulation of ventilation systems under the influence of mine fires and other emergencies on five hardrock mines. For each of the selected mines, the ventilation system, the source of the used ventilation data, and the preparation for computer simulations are outlined. Volume II comprises figures and tables for appendixes A and B. Research done under contract J0285002 by Michigan Technological University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; 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 81(3)–81. Precalculation of the Effect of Fires on Ventilation Systems of Mines. Volume III, Figures and Tables, by Rudolf E. Greuer. June 27, 1979. 215 pp. 30 figs. This report contains the practical application of a computer program for the simula-

tion of ventilation systems under the influence of mine fires and other emergencies on five hardrock mines. For each of the selected mines, the ventilation system, the source of the used ventilation data, and the preparation for computer simulations are outlined. Volume III comprises figures and tables for appendixes C through E. Research done under contract J0285002 by Michigan Technological University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; 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 82–81. Proceedings of the Fifth WVU Conference on Coal Mine Electrotechnology, July 30–31, August 1, 1980, ed. by Nelson S. Smith. October 1980. 396 pp. 209 figs. This report is a compilation of papers presented at the 5th West Virginia University conference on coal mine electrotechnology in Morgantown, W. Va., July 30–31 and August 1, 1980. The papers cover areas of electromagnetic-power systems, power systems, monitoring and control, and communications. Research done under contract J0100049 by West Virginia University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; 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 83–81. 1979 Bureau of Mines Sampling Sites and Analytical Results for Samples Collected in the Chugach National Forest, Alaska, by Uldis Jansons. 1981. 229 pp. 6 figs. The Bureau of Mines and the U.S. Geological Survey are conducting a mineral resource-reserve evaluation of the Chugach National Forest as part of an interagency resource evaluation under Roadless Area Review and Evaluation (RARE II) aegis mandated by the National Forest Management Act of 1976 (Public Law 91–190). The area was sampled extensively by the Bureau in 1979 and sample site locations and analytical results are presented in a computer listing and five maps. The samples were analyzed in Anchorage, Alaska, and Wheat Ridge, Colo., by commercial laboratories using standard techniques. Research done by Alaska Field Operations Center. Available for reference at the Office of the Director, Division of Mineral Land Assessment, Bureau of Mines, Washington, D.C.; Bureau of Mines facilities in Anchorage, Fairbanks, and Juneau, Alaska; 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 84–81. In-Situ Leaching Studies of Uranium Ores—Phase V, by D. C. Grant. May 1980. 593 pp. 92 figs. In situ uranium leaching involves passing a lixiviant and oxidant solution through the uraniferous ore body. As the solution progresses through the ore body, the uranium is oxidized to a soluble state and taken into solution. The uranium-laden solution is removed from the ore body and the uranium is recovered in a plant on the surface. In this study, a laboratory technique for simulating the underground leaching process was developed and used to determine the effects of leaching variables on the permeability, uranium recovery, and ore-aquifer environment. Agitation and column leach tests were conducted using ore samples from Wyoming and Texas. The information obtained from these tests provides a better understanding of the leaching process. Research done under contract H0262004 by Westinghouse Electric Corp. R & D Center. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS, PB 81–222739; paper copy price code A25.

OFR 85–81. Hazardous Surface Openings to Abandoned Underground Mine—Nevada, by W. G. Freeman, R. M. Jones, J. G. Babcock, M. L. Christo, and R. A. Noel. June 1980. 747 pp. 57 figs. The purpose of this study was to gather a representative sampling of underground mines in various counties in the State of Nevada and to determine which of these mines had openings representing a hazard or threat to the general public. Based on the selection of 157 target mining districts, 200 inactive mines were selected and visited as a representative sample. The sample was categorized and listings were made by county, type of opening, degree of risk associated with the opening, and the closure method recommended. Each mine site was photographed and the name, location, commodity, historical and geologic value, future mining potential, and degree of hazard was recorded. Laws, regulations, and ordinances pertinent to closure of inactive mines were researched and summarized. It was concluded that permanent mine closure is seldom desirable; low cost, easily installed closures of a semipermanent-to-temporary variety are most appropriate; and sufficient legal mechanisms exist to protect the public if and when applied. Research done under contract J0295039 by International Mining Consultants, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va., National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–223414; paper copy price code A99.

OFR 86(1)–81. Recommended Guidelines for Oxygen Self-Rescuers—Volume I, Underground Coal Mining, by D. Randolph Berry and Donald W. Mitchell. June 1981. 52 pp. 4 figs. The Bureau of Mines awarded a contract for the provision of recommendations on the safest, most practical methods for complying with new regulations requiring that

all underground coal miners have a self-contained, self-rescuer (SCSR)—a device capable of supplying, in an emergency, 1 hour of self-contained oxygen (no breathing of mine air). This report presents information and recommendations that could be used during the early stages of nationwide compliance, especially in the areas of inspection, testing, and underground storage of SCSR's. This volume contains an executive summary, introduction, definitions, recommended guidelines for district managers and mine operators, and a storage plan checklist and sample form. Research done under contract J0199118 by Foster-Miller Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–225872; paper copy price code A04.

OFR 86(2)–81. Recommended Guidelines for Oxygen Self-Rescuers—Volume II, Appendices, by D. Randolph Berry and Donald W. Mitchell. June 1981. 265 pp. 31 figs. This report comprises the appendixes that explain and document the recommendations for the guidelines for oxygen self-rescuers. The report covers (1) a discussion of the recommended guidelines, (2) worldwide use of oxygen self-rescuers, (3) hypothetical use of oxygen self-rescuers in post-1972 coal mine explosions and fires, (4) vibration testing of self-contained, self-rescuers (SCSR's), (5) testing of in-service SCSR's, (6) discussions with representatives of underground coal mining, (7) recommendations for SCSR storage containers, (8) example SCSR storage plans, (9) testing of in-service compressed oxygen SCSR's, and (10) 30 CFR 75.1714, 30 regulations pertaining to self-rescuers. Research done under contract J0199118 by Foster-Miller Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–225880; paper copy price code A12.

OFR 87–81. Development and Demonstration of Improved Truck Ladders, by G. Gavan, P. Mate, D. Strassel, and K. Conway. Sept. 28, 1979. 335 pp. 178 figs. Analysis of reported injuries for off-highway haul trucks indicated that 42.7 pct were slip and fall, and of these, 34.1 pct occurred mounting or dismounting the machine. Redesign of the lower steps was concluded to provide the most overall improvement for increased safety and accident reduction. Various existing, innovative, and conceptual designs were reviewed and evaluated. The most promising designs were the four-spring-supported lower steps and the center-tube-mounted lower steps. Both steps proved to be viable designs by passing human factors and survivability tests conducted at a large copper mine. Research done under contract H0282001 by Woodward Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–223406; paper copy price code All.

OFR 88–81. Evaluation of Intrinsically Safe Instruments and Apparatus for Use in Underground Coal Mines, by J. M. Kurtz, A. A. Bartkus, and P. J. Schram. May 1980. 479 pp. 22 figs. Ten methane monitoring systems and machine control circuits were examined and tested according to the requirements in CFR Title 30, Parts 17 and 27, the Standard UL 913, and the document "Test Requirements for Instruments or Apparatus to be Considered for M.E.S.A. Intrinsically Safe Certification (Tentative)." The test results indicate that none of the products complied with all parts of all requirements as interpreted. Research done under contract J0188046 by Underwriters Laboratories Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; 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 89–81. Mineral Land Assessment of the West Portion of Western Chichagof Island, Southeast Alaska, by J. C. Still and K. R. Weir. 1981. 168 pp. 90 figs. During 1978–79, the Bureau of Mines surveyed the mineral potential of the west portion of western Chichagof Island as part of the examination of the western Chichagof and Yakobi Islands wilderness study area, Tongass National Forest, Southeast Alaska. The study included literature and claims records searches; field examinations of the reported mines, prospects, or claims; and field evaluation of geochemical anomalies noted by the U.S. Geological Survey during concurrent investigations. Two mineralized areas were found. One, called the Slocum Arm molybdenum area, is estimated to have moderate potential for the development of porphyry or vein-type molybdenum deposits. The other, called the West Coast gold area, is estimated to have moderate potential for the development of fault controlled gold-silver lode deposits. Research done by Alaska Field Operations Center. Available for reference at the Office of the Director, Division of Mineral Land Assessment, Bureau of Mines, Washington, D.C.; Bureau of Mines facilities in Anchorage, Fairbanks, and Juneau, Alaska; 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 90–81. Silencing the Flame Channelling Process, by James A. Browning. Feb. 27, 1980. 32 pp. 15 figs. Conventional flame channeling operates continuously at over 120 db—flame drill channeling operates at a maximum of 95 db. The latter process was developed under this program. Individual drill holes are spaced to leave narrow rock webs. Sound and dust passing from the holes are effectively treated by a muffler and water injection. Research done under contract H0387017 by Browning Engineering Corp. Available for reference

at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-221996; paper copy price code A03.

OFR 91–81. Recovery of Heavy Metals From High Salinity Geothermal Brine, by Eldon P. Farley, El Lorraine Watson, Digby D. MacDonald, Robert W. Bartlett, and Gopala N. Krishnan. December 1980. 130 pp. 48 figs. Large quantities of high salinity geothermal brine from the Salton Sea Geothermal Area, Calif., contain significant amounts of Pb, Zn, Fe, and Mn. A simple method of treating large volumes of spent brine is required to economically recover the valuable nonferrous metals. Results from a 2-year laboratory investigation of sulfide precipitation are discussed, including the condition for achieving maximum precipitation of the valuable heavy metals while minimizing precipitation of Fe and Mn, which have little economic value. In the first year, the study was initiated and guided by computer thermodynamic modeling. The second year has been devoted to the operation and optimization of the sulfidation process at a continuous bench scale. Research done under contract J0188076 by SRI International. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-222218; paper copy price code A07.

OFR 92–81. Manpower and Training Model for the Mining Industry, by David Siedenstrang, Dwight Ellingwood, and John Short. April 1980. 219 pp. 18 figs. This report was prepared to illustrate a model for projecting employment and training demands in the coal mining industry. The report details a methodology developed to translate forecasts of regional coal production and mining productivity into estimates of training incidences necessary to meet both the MSHA safety regulations and internal skills training demands. The model is responsive to estimates of employment turnover and the job mobility of the coal mining work force as configured from a summarization of job histories of approximately 15,000 miners collected during a mine site assessment of 47 coal mining operations located throughout the Nation. In addition, historical production, productivity, and employment data are examined for the metal and nonmetal mining industries and projections of safety-related training demands are presented. Research done under contract J0357109 by John Short & Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-222325; paper copy price code A10.

OFR 93–81. Development and Evaluation of Polymer Modified Portland Cement Concrete Lagging for Mine Openings, by R. D. Eash and H. W. Kirchner. Oct. 1, 1980. 127 pp. 38 figs. This report presents results of a study to develop and test a Saran latex modified portland cement concrete lagging to be used as a replacement for wood lagging in underground mining. Two hundred and twenty latex modified concrete lagging were produced and shipped to the Bunker Hill Co. in Kellogg, Idaho, for installation in their mine at the 17th level. The lagging are performing satisfactory after 22 months of exposure in the mine. The Dow concept replaces wood systems by using reinforced latex concrete which outperforms and outlives wood systems, is more cost effective, and is completely nonflammable. Research done under contract H0262046 by The Dow Chemical Co. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-223331; paper copy price code A07.

OFR 94(1)–81. Sulfur Pollution Control. Phase I. The Disposal Program (Sections 1 Through 4), by Michael Rieber, Robert Fuller, and Benjamin Okech. January 1981. 362 pp. 1 fig. This study develops the data base and an economic analysis of the primary sectors prerequisite to the regional projection of the supply side of the U.S. sulfur industry. The probable future course of sulfur pollution and process control in the United States and elsewhere as it impacts, by the production of sulfur values, the domestic Frasch industry, is estimated. A regional determination of the present and future U.S. sulfur supply market is presented. Research done under contract J0188144 by University of Arizona. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Boulder City, Nev., Pittsburgh, Pa., and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-222796; paper copy price code A16.

OFR 94(2)–81. Sulfur Pollution Control. Phase I. The Disposal Program (Sections 5 Through 7), by Michael Rieber, Roger Fuller, and Osmario Dellaretti. January 1981. 189 pp. Sulfur recovery from domestic sour natural gas and petroleum refining is estimated on a current basis and projected to the mid-1990's on a regional basis. The former depends importantly on gas production projections for the Overthrust Belt and the associated H_2S. The latter depends largely on projected increases in the sulfur content and weight of imported crude oils, total crude oil imports, and anticipated refinery response. Research done under contract J0188144 by University of Arizona. Available for

reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Boulder City, Nev., Pittsburgh, Pa., and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-222804; paper copy price code A09.

OFR 94(3)–81. Sulfur Pollution Control. Phase I. The Disposal Program (Sections 8 and 9), by Michael Rieber, Benjamin Okech, and Roger Fuller. January 1981. 262 pp. Sulfuric acid production from sulfur-based acid plants and smelters is analyzed. Industry competition, with particular emphasis on voluntary versus abatement acid, is reviewed. Regionally, even though smelter acid is geographically limited, competition is at least moderate. Production costs for both acid plants and smelters are estimated. Due to the byproduct nature of the latter, assigned costs and acceptable producer price are much the lowest. Large-scale users will prefer sulfur-based acid production if the heat value of the reaction can be utilized as a steam credit. Additionally, voluntary acid is a more stable supply source than smelter acid. Voluntary acid output is a reaction to price and demand conditions. Abatement acid production depends on APC implementation and the state of the relevant metals markets. Even if copper, lead, and zinc output remains at current levels, if current EPA regulations are implemented, acid output will approximately double. An output forecast is made based on APC regulations, implementation, and estimated metals production. As a direct competitor to U.S. acid and as indirect competitors to Frasch sulfur, Canadian and rest-of-world acid output is reviewed. Research done under contract J0188144 by University of Arizona. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Boulder City, Nev., Pittsburgh, Pa., and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-222812; paper copy price code A12.

OFR 94(4)–81. Sulfur Pollution Control. Phase II. The Impact of Stack Gas Cleanup on the Sulfur Mining Industry of Texas and Louisiana, by Michael Rieber, James M. Barker, and Michael Worrall. January 1981. 114 pp. 5 figs. The impacts of various (reduced) levels of Frasch sulfur production on the States of Texas and Louisiana are analyzed. The analytic time basis is 1979. Industry labor and output characteristics are developed on a company and mine basis. State and local impacts (to the level of independent school districts) are developed on a scenario basis. The measures include income, unemployment, and taxes. Some data are presented on energy and water use. Research done under contract J0188144 by University of Arizona. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Boulder City, Nev., Pittsburgh, Pa., and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-222820; paper copy price code A06.

OFR 95–81. A Computer Program To Estimate Costs for Process Evaluation, by P. L. Placek and D. A. Elkins. March 1981. 233 pp. 14 figs. This report presents a computer program for cost estimation to evaluate many types of metallurgical and chemical processes. The program provides a convenient means of obtaining comparative costs for frequent process modifications needed to guide research. Estimation of overall process and unit operation costs call attention to sources of high cost that need further study. All costs except those for and factored from direct labor are scaled by material balance data so that effects of changes in the process flowsheet or in plant capacity can be determined easily. The report includes a description of the main routine, subroutines, and data cards needed and includes examples of computer output, a diagram of the program, and listings of all routines Research done by Salt Lake City Research Center. Available for reference at Bureau of Mines facilities in Salt Lake City, Utah, and Avondale, Md. Copies of this report will not be available for purchase.

OFR 96–81. Conceptual Designs of Retaining Structures for Open Pit Backfilling, by Serge Rudchenko, Ramon Upsahl, John P. Ashby, and G. A. Mathieson. February 1981. 170 pp. 71 figs. This report presents a study to determine the potential use of retaining structures in open pit backfilling. The report contains the results of research and review of an open pit mine environment, mine waste disposal, and past and current use of retaining structures. The development of specific structures, the culvert-tunnel concept, and an anchor block retaining concept are included. In addition, the cost benefit of retaining structures used for in-pit backfilled waste is presented. Research done under contract J0205003 by Skilling, Helle, Christiansen, Robertson, Inc., and Golder Associates. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md. Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-225799; paper copy price code A08.

OFR 97–81. Market Instability in the Metal Industries, by John E. Tilton and William A. Vogely. September 1980. 191 pp. 7 figs. This study examines the underlying factors responsible for market instability in the metal industries; considers recent trends in inventory behavior and business cycle fluctuations that suggest instability is growing more severe; and investigates the consequences of instability for various metal markets, for investment in new mines and processing facilities, and for U.S. imports of mineral commodities. Research done under contract J0188044 by Pennsylvania State University. Available for reference at Bureau of Mines facilities in Juneau, Alaska, Denver, Colo., Pittsburgh, Pa., and Spokane, Wash.; 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 98–81. Study of Respirable Dust Outby the Working Face of a Coal Mine, by R. L. Rankin and S. J. Rodgers. Mar. 31, 1980. 180 pp. 33 figs. The objective of this investigation was to conduct surveys of respirable dust concentrations in coal mining operations at locations outby the working face. The results of these surveys were directed toward (1) identifying outby dust sources, (2) evalu-

ating the severity of the major dust sources, (3) establishing dust sampling frequency, (4) establishing dust sampler locations, and (5) assessing the areas of influence of the dust sources. The study included dust sampling of only nonhigh-risk personnel and areas at six different mines. Thirteen continuous mining, four longwall, and two conventional mining sections were sampled. The severity of outby respirable dust sources such as load points, runways, dump points, beltways, transfer points, and main haulage operations were characterized and areas within the mine ranked according to severity. Information on engineering controls was also acquired. Guidelines for implementing a dust sampling program are presented and include sampler locations, ventilation surveys, dust surveys, effects of shift-to-shift variations, and sampling frequency. Research done under contract J0366022 by MSA Research Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–236762; paper copy price code A09.

OFR 99–81. Development of a Through-the-Earth Monitor System, by Arthur D. Little, Inc. December 1980. 31 pp. 7 figs. The objective of this program was to design and build a self-contained system for remote monitoring of the atmosphere in mines. The system developed uses the mine pager phone line as the primary communication channel and also has the capability of using 208 Hz in the ELF band for wireless transmission through the band. The depth for through-the-earth transmission is expected at about 80 to 90 meters in high conductivity soil and is limited by the noise level in the ELF band-pass filters. The underground components of the through-the-earth monitor system are energized by mine power through a battery charger-storage battery power supply. In the event of mine power failure, the battery capacity is more than sufficient for 1 week's operation with interrogations every 4 hours. Research done under contract H0177098. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–237646; paper copy price code A03.

OFR 100–81. Development of Noise Control Technology for Pneumatic Jumbo Drills, by D. L. George and N. J. Matteo. November 1980. 61 pp. 19 figs. The objective of this program was to investigate, design, develop, and demonstrate noise control techniques that could be designed into new jumbo drills. Techniques used in this program were an isolated drill guide, damped acoustical enclosure, standard mufflers, and a specially designed silencer for the air egress of the enclosure. Conventional mufflers were used for the feed and rotational motor exhausts. The Ingersoll-Rand VL-120 drill with a standard UDM-14 slide were used as the test and development subjects. An enclosure was developed that encompassed the drill and slide, and at the same time did not interfere with performance or ease of operation. Standard construction materials were utilized throughout the program. Sound pressure levels of the unit as-received were 113 dbA at the operators position, and 101 dbA at a 7-meter location. After all of the noise reduction techniques had been implemented, the sound pressure levels were 102 dbA at the operators position, and 87 dbA at a 7-meter location. A conceptual design for an improved quiet drill is also presented. Research done under contract H0395029 by Ingersoll-Rand Research, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–237414; paper copy price code A04.

OFR 101–81. Modifications Made to an Interactive Computer System for Evaluating Coal Mine Illumination, by Robert Goldstein. August 1980. 27 pp. 6 figs. A computer system for calculating the illumination on coal mine surfaces due to machine-mounted lights is described. Utilizing numerical models of mining machinery and measured data on luminaire output characteristics, the program computes the foot-candle levels incident on the mine surfaces. Shadowing effects of the machine are taken into account. The system operates, interactively from a Tektronix 4014 graphics terminal that handles all input-output functions. The software is installed on a Cyber 74 computer that communicates with the terminal by a telephone line. Several modifications to the system are described, the most important of which provides the ability to analyze surface mine lighting. Research done under contract H0282038 by Mathematical Applications Group, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–236754; paper copy price code A03.

OFR 102–81. An Assessment of Thin Seam Mining System Technology, by J. Clark and J. H. Caldon. July 1980. 379 pp. 55 figs. The objective of this study was to determine the state-of-the-art in underground, thin-seam mining systems, to identify new technology and procedures that would reduce the hazards in thin-seam mining, and to recommend areas for further research. The study was carried out in two phases, the first was devoted to a survey of authoritative literature. The practices adopted in various mining countries were analyzed and comparisons made to identify machines and methods with the potential for application in the United States. Published figures on U.S.

bituminous coal reserves show the high proportion contained in thin seams and U.S. accident statistics demonstrate that the risk is greater in thin-seam operations. A comparison was made with the experiences of foreign operations. The second phase proceeded along two separate avenues to examine the distinctive problems associated with seam thicknesses above and below 30 inches. Current systems of mining appropriate to seams greater than 30 inches were elaborated and compared by a simulation exercise in terms of safety, production, and cost. For seams below 30 inches, less conventional systems, some presently disused, were studied and their potential evaluated; the research and development work necessary to make them viable are indicated. Research done under contract J0199122 by British Mining Consultants Ltd., Enfield, Middlesex, United Kingdom. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–237455; paper copy price code A17.

OFR 103–81. Development of Tests and Criteria To Evaluate Grounding Systems, by Wils L. Cooley and Robert L. McConnell. November 1980. 176 pp. 77 figs. This report covers several aspects of mine safety ground systems, primarily for underground coal mines. The design of a combined ground fault-ground check monitoring system is presented. An analysis is made of grounding systems for dc shuttle cars. Complete resistance data and results of physical inspections of self-salting ground rods are presented. A detailed resistance and economic analysis is presented for the use of composite materials for building inexpensive and effective ground beds in high-resistivity areas. The desirability of penetrating the coal seam with a borehole safety ground is investigated. A report is made of a mine substation grounding and bonding workshop. Research done under contract J0199116 by West Virginia University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–238354; paper copy price code A09.

OFR 104–81. Study To Determine the Feasibility of Man-Trip Training. Phase I Report, by Daniel R. Walton, Patricia F. Webb, and William T. Liggett. Jan. 23, 1979. 182 pp. 58 figs. This report presents a study to explore the potential of utilizing the transport time required to move coal miners to and from working sections. Consideration was given to all forms of training and presentation media, taking into account such environmental factors as noise, dynamic interferences, visibility, physical constraints, and contaminants. Indications of management and worker attitudes toward worker-trip training were also assessed. The final product was a proposed prototype training system for worker-trip training. Research done under contract J0188032 by Management Engineers, Inc., and Westinghouse Electric Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburg, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–237471; paper copy price code A09.

OFR 105–81. Development of a Personal Monitoring Field Kit for NO_2 and NO, by MDA Scientific, Inc. Jan. 30, 1981. 22 pp. 9 figs. A complete field kit for performing onsite determinations of individual employee time weighted average (TWA) exposures to nitrogen dioxide (NO_2) and nitric oxide (NO), has been developed. This report provides background information and experimental data validating the use of the kit with confidence to ± 10 percent accuracy. Research done under contract H0387019. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–237406; paper copy price code A02.

OFR 106–81. A Training Program for Conventional and Raise Drill Shaft Construction Personnel, by J. Bongarra, Jr., W. Carswell, K. Golas, E. Shriver, S. Shriver, and C. Condon. July 1979. 414 pp. 50 figs. This report describes the development of the instructional design and content of a training program for shaft construction miners and supervisers. The recommended training approach is based on the results of needs, tasks, and competency analyses of jobs performed by conventional shaft sinking and raise drill personnel. Learning objectives were derived from the task analyses and the appropriate training delivery system was chosen using a selection technique that employed learning algorithms. The training is directed toward improving the safety and efficiency of constructing shafts by new hired and experienced miners and supervisors. A self-paced, self-teaching, modular approach to training, using criterion-referenced tests was proposed. Training requirements for conventional shaft sinking and raise drilling were described. Training program content was detailed in the form of module and lesson design approaches. The report also recommends a method for developing, implementing, and validating the training program. Research done under contract J0387227 by Kinton, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg, Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural

Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–237372; paper copy price code A18.

OFR 107–81. Proceedings of the Fourth WVU Conference on Coal Mine Electrotechnology, August 2–4, 1978, ed. by M. Dayne Aldridge. Oct. 1, 1978. 521 pp. 231 figs. This report is a compilation of papers presented at the 4th West Virgina University Conference on Coal Mine Electrotechnology in Morgantown, W. Va., on August 2–4, 1978. The papers cover areas of electric power, electronic communications, detection and location of trapped miners, and electronic sensors and monitoring systems. Report prepared under contract J0188034 by West Virginia University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; 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 108–81. Development of a Portable Gas Analyzer for In-Mine Personnel Monitoring, by Edward A. McClatchie and Irvin G. Burough. Aug. 15, 1980. 129 pp. 44 figs. Based on a pressure-modulated absorption technique, a novel nondispersive electrooptical gas analyzer has been designed, fabricated, and tested. Key features of this new gas analyzer technique include long-term zero and calibration stability. The technique was investigated for carbon dioxide (CO_2), carbon monoxide (CO), methane (CH_4), and nitrogen dioxide (NO_2). The analyzer was capable of measuring the three species CO, CO_2, and NO_2. It is a compact (300 cu in) package, is battery powered, and weighs 15 lb. Approximately 30 readings of each gas may be made on a single battery charge. Operating principles and performance data are included in the report. Research done under contract H0230050 by Andros Analyzers, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–236770; paper copy price code A07.

OFR 109–81. Recovery of Metal Values Prior to Reclamation of Mined Areas in the Southwest, by David D. Rabb. June 30, 1980. 49 pp. 3 figs. The objective of this investigation was to determine the feasibility of recovering precious metals from abandoned mine dumps in Mohave County, Ariz. Thirteen mine dumps and/or tailings ponds were sampled in the vicinity of Oatman, Ariz. Analysis of 39 samples showed that two sites had sufficient gold and silver to merit metallurgical testing. Cyanide heap leaching tests showed that about 30 percent of the precious metals could be extracted in 10 days from either site. Lime and cyanide consumption were low. It was concluded that extraction might be economically feasible. Research done under contract J0295023 by University of Arizona. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.: and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–236796; paper copy price code A03.

OFR 110–81. Chromium Substitution in Stainless Steels, by S. Floreen. November 1980. 80 pp. 15 figs. A series of vacuum-melted austenitic stainless steels were investigated that contained zero to 18 percent Cr and additions of Mo, V, Cu, Si, Al, Mn, or N. The corrosion resistance was evaluated in a number of environments. The results indicate that it is feasible to develop a stainless steel containing approximately 9 percent Cr along with additions of Mo and possibly Cu and V that would have corrosion resistance comparable to 18 percent Cr steels in less severe environments. The mechanical properties, fabricability, and weldability of such an alloy would be acceptable. Research done under contract J0295070 by Inco Research and Development Center, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–235475; paper copy price code A05.

OFR 111(1)–81. Analysis of Work Areas and Tasks To Establish Illumination Needs in Underground Metal and Nonmetal Mines. Volume I of II, by W. H. Crooks, K. L. Drake, T. J. Perry, N. D. Schwalm, B. F. Shaw, and B. R. Stone. Sept. 18, 1980. 254 pp. 55 figs. The objective of this study was to identify the characteristics of underground jobs and work locations in metal and nonmetal mining to determine the illumination needs and to suggest improvements for safety. Four analyses were conducted: (1) on-site measurement and evaluation of underground work sites, (2) task analysis of underground jobs, (3) laboratory analysis of the gonioreflectance of rocks and minerals from sampled mines, and (4) identification and analysis of the accidents and the employment distribution of this industry. The report describes the illumination characteristics of the underground jobs and locations and suggests that illumination needs are primarily determined by the tasks being performed. Research done under contract J0387230 by Perceptronics, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural

Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–236804; paper copy price code A12.

OFR 111(2)–81. Analysis of Work Areas and Tasks To Establish Illumination Needs in Underground Metal and Nonmetal Mines. Volume II of II: Appendices, by W. H. Crooks, K. L. Drake, T. J. Perry, N. D. Schwalm, B. F. Shaw, and B. R. Stone. Sept. 18, 1980. 239 pp. 19 figs. The objective of this study was to identify the characteristics of underground jobs and work locations in metal and nonmetal mining to determine the illumination needs and to suggest improvements for safety. Four analyses were conducted: (1) onsite measurement and evaluation of underground work sites, (2) task analysis of underground jobs, (3) laboratory analysis of the gonioreflectance of rocks and minerals from sampled mines, and (4) identification and analysis of the accidents and the employment distribution of this industry. Volume II contains the appendices. Research done under contract J0387230 by Perceptronics, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–236812; paper copy price code A11.

OFR 112–81. Evaluation of Proximity Warning Devices. Phase II, by T. C. Green, J. P. Cater, and J. H. Nixon. Feb. 13, 1981. 40 pp. 14 figs. A two-phase program evaluated commercial proximity warning devices and then served to design and develop an automatic electrostatic field strength measurement device with improved performance. The phase I program consisted of test and evaluation of three commercial proximity warning devices, all of which operate on the principle of electrostatic field intensity measurement for determining proximity to high-voltage powerlines. Performance testing of these devices utilized full-scale cranes and powerline systems and a scale-model facility. Under the phase II program, a microprocessor-based data acquisition system was designed and developed to collect and measure field strength at distributed points around the crane boom. This unit measures the field strength about a crane boom using 17 distributed sensors. Keyboard control is provided for the equipment operator. Measured field strength values are displayed on a line printer and recorded on magnetic tape. Laboratory testing of this unit demonstrated performance characteristics and field strength measurement accuracy within the design goals. Research done under contract J0188082 by Southwest Research Institute. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–237513; paper copy price code A03.

OFR 113–81. The Spontaneous Heating of Coal and the Role of Moisture Transfer, by J. B. Stott. July 1980. 78 pp. 26 figs. This report describes the occurrence of spontaneous heating in an 800-metric-ton heap of Wyoming coal. The major part of the report deals with the oxidation of Pittsburgh seam and Wyoming subbituminous coal and describes an experiment in which 1 metric ton of Wyoming coal is stored in a 5-meter-long insulated container while air is passed through. Temperature rises, rates of oxygen absorption, and gas compositions of the air stream are measured. The report relates the results of the experiments to a theory of spontaneous heating, which stresses the importance of the moisture content of coal and the relationship between the heat necessary to evaporate water to the heat available from coal oxidation. Research done under contract J0395146 by University of Canterbury, Christchurch, New Zealand. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; Mining Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; 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 114–81. Coal Waste Dewatering Systems, by Stanley P. Jacobsen, William Roushey, and Earl L. Rau. Feb. 6, 1981. 133 pp. 16 figs. Samples of fine coal refuse were obtained from 11 coal preparation plants throughout the United States. The samples were characterized by ash analysis, particle size, and mineral composition. From the characterization, geographical locations, and the dewatering equipment being used by the plants, five sites were selected for obtaining bulk fine refuse samples. The selected coal preparation plants were used for final dewatering thickeners followed by a vacuum disk filter, a filter press, a belt press filter, a centrifuge, and a settling pond. None were using thermal drying. The moisture content of the final cake ranged from approximately 23 to 50 pct, depending upon the feed material, flocculant addition, and the type of equipment. The filter press gave the lowest moisture content followed by a belt press and then either a centrifuge or vacuum filter. The centrifuge products were all dried to an approximate 5-pct moisture in a thermal dryer. Research done under contract J0205012 by Colorado School of Mines Research Institute. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mining Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–244501; paper copy price code A07.

OFR 115–81. Continued Research on Combined Fire/Rot Retardant Treatment for Wood Mine Timber, by William H. Holley. October 1980. 81 figs. Thirteen additional preservative-fire retardant systems were applied to Ponderosa pine and evaluated for flammability both before and after water leaching. The more promising four systems were given a thorough evaluation for flame spread, toxic gas and smoke density levels, resistance to decay, and compressive strength. The most promising system on the basis of history of usage in the mine, ease of application, and low cost as well as overall performance is the Fyreprufe-ACC Albi 107A-144 combination. A survey of inspection tools and instruments, identified equipment that could be assembled into an inspection kit for use in determining the extent of decay and/or impregnant retention levels in mine timber. A literature search identified those high fire hazard areas found in a typical mine. Timber and other wooden structures used in such areas should be treated with an acceptable fire-retardant system. A survey of insurance companies revealed that the use of such treated timber in the mines would probably have little or no impact on the rate structure. Research done under contract J0166068 by Springborn Laboratories, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mining Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–244493; paper copy price code A05.

OFR 116–81. Tape Recording and Triggering Systems, by Kenneth R. Sites and Lawrence A. Millonzi. June 7, 1980. 16 pp. 2 figs. Under this program two tape recording and triggering systems were developed and delivered for use in the Bureau of Mines microseismic program. The systems are designed to improve the effectiveness of the Bureau-owned Sangamo 3500 series and SABRE VI instrumentation tape recorders. The system is designed to capture random microseismic data, digitize and temporarily store these data, start the tape recorder, and then transfer the data to magnetic tape for permanent storage. The system is designed to pack data on tape such that the tape may be simply played back through galvo drivers onto an oscillograph such that a continuous series of analog records, with corresponding time of day information, are reproduced without excessive oscillograph paper waste or the need for the operator to search for valid events. Research done under contract H0282026 by Science Applications, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mining Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–243248; paper copy price code A02.

OFR 117–81. Application of a Hydraulic Borehole Mining Apparatus to the Remote Extraction of Coal. Interim Report, by John B. Cheung, George H. Hurlburt, Lowell E. Scott, and Scott D. Veenhuizen. September 1976. 87 pp. 52 figs. This report presents the results of a program to demonstrate the technical feasibility of hydraulic borehole coal mining. The hydraulic borehole method of coal mining involves inserting a hydraulic mining device into a borehole that has been drilled from the surface into the underground coalbed. The borehole mining device issues a jet of water under high pressure, which breaks the coal. The pieces of coal and water form a slurry that flows to the base of the borehole where it is pumped to the surface. Phase I of the program encompassed the design, fabrication, and factory-testing of a hydraulic borehole mining device. The program was successfully completed at the Wilkeson-Carbonado Coalfield near Wilkeson, Wash. The technical feasibility of hydraulic borehole coal mining was demonstrated by mining 32 tons of coal at a depth of about 75 feet over a period of 4 hours. Research done under contract H0252007 by Flow Industries, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; Mining Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; 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 118–81. Field Test of Deep Cutting Double Arm Shearer, by Jonathan E. Ludlow. March 1981. 159 pp. 53 figs. A field test was conducted to demonstrate the deep cutting principle in relation to the creation of airborne respirable dust when longwall mining with a double-ended, ranging drum shearer. The test was carried out on the 3 North longwall at the Quarto No. 4 Mine in Clairington, Ohio. Continuous recordings of dust levels were made at midface and near the tailgate on 27 shifts during which time 81 mining cycles took place. Drum speed and number of picks per line were varied systematically. At the midface position there was a strong association between drum speed and number of picks with the level of airborne respirable dust. Drum speed had a much stronger effect than the number of picks over the experimental range, since a halving of drum speed reduced dust levels by approximately 60 pct while removal of every other vane pick resulted in only a 20 pct reduction. At the tailgate position, however, neither effect was strongly apparent. A tendency for the slower drum speeds to be associated with reduced power consumption and higher haulage speeds (and therefore production rates) was also noted. It is recommended that longwall operators operate at the lowest available drum speed wherever possible. Research done under contract J0199092 by Foster-Miller Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and

Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-246480; paper copy price code A08.

OFR 119-81. Retractable Bit System, by Walter W. Svendsen, Ronald E. Cozad, and John F. Hoffmeister. Dec. 20, 1980. 105 pp. 22 figs. A prototype retractable bit system was developed consisting of a one-piece replaceable diamond set bit, a modified core barrel, bit changing tools, and surface components that allow activation of the system. Drilling with the retractable bit system is conducted in the same manner as present core drilling, except when the bit becomes worn the bit is changed with the drill string left in the hole. The operations in changing the bit are similar to those required in changing inner core tube assemblies with the wireline cable. The prototype testing indicates that this retractable bit system is feasible. It has shown reasonable reliability, but an extensive research program will be required to determine if sufficient reliability and increased productivity can be achieved to justify development of the system as a commercial product. Research done under contract H0272004 by Longyear Co. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-104340; paper copy price code A06.

OFR 120-81. Rod Mill Grinding: Analysis of Size Reduction Kinetics and Material Transport, by Douglas W. Fuerstenau. July 1980. 33 pp. 9 figs. A detailed experimental study of breakage kinetics in a batch rodmill indicates that while the system is inherently nonlinear, the feed disappearance kinetics for the finer sizes and the coarser sizes at high holdups is well represented by first-order behavior. A linearized grinding model that results from the first-order Taylor's series expansion of the breakage rate expression was found to give good simulations of the mill product size distributions without recourse to any parameter improvement routine. Material transport through rodmills was evaluated by investigating the effect of operating variables on the holdup and residence time distribution of particulate solids flowing through the mill. Identical experiments performed in a continuos ballmill helped delineate the fundamental differences in particulate transport through these two types of mills. Mechanistic interpretations of the observed transport phenomena are presented, and their implications in the context of tumbling mill analysis and design are emphasized. Research done under grant G0177144 by University of California. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mining Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-104357; paper copy price code A03.

OFR 121-81. Innovations for Explosionproof Electrical Enclosures, by R. J. Gunderman. April 1980. 209 pp. 80 figs. Explosionproof electrical enclosures for coal mine face equipment have been of the same basic design for many years without significant change. With the goal of improving safety, health, and productivity, characteristics for potential improvement were investigated through interviews, visits to mines, and studies. Areas identified for improvement included rapid venting of pressure buildup due to an internal explosion, quick and easy entry or removal of cable entrances, and a quick and easy cover removal for rapid component access. Concepts were identified and evaluated, and the more promising devices were fabricated and tested. Encouraging results from initial tests led to further design refinement and establishment of design guidelines. These design guidelines for a pressure vent and for an elastometric grommet-type cable entry are described along with the testing used. Research done under contract H0357107 by Dresser Industries, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-104936; paper copy price code A06.

OFR 122-81. Study of Air Compressor Hazards in Underground and Surface Mines, by Martin B. Treuhaft and B. Chope Dial. January 1981. 93 pp. 4 figs. This report analyzes air compressor hazards in mines and presents guidelines for eliminating fires, explosions, and other operational hazards that can result when compressors are used in coal and metal-nonmetal mining applications. Government data bases and reports for mine accidents are reviewed and analyzed. Foreign and domestic standards, regulations, and codes governing air compressor usage are discussed and compared. Industry trends toward air compressor usage are discussed and their impact on compressor safety is analyzed. Recommendations are directed toward MSHA, mine management, and the Bureau of Mines regarding their involvement in accident reporting and prevention. Research done under contract J0100006 by Southwest Research Institute. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mining Safety and Health Administration, Arlington, Va.; Mining Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-105164; paper copy price code A05.

OFR 123(1)–81. Finite Element Analysis Applied to Resin and Mechanical Roof Bolting Systems for Strata Bound Deposits. Volume I. Final Report, by J. C. Gerdeen, G. L. Viegelahn, V. W. Snyder, P. M. Schwab, H. Schuyten, C. J. Wick, and T. J. Collison. Aug. 31, 1976. 143 pp. 54 figs. The purpose of this program was to find the relationships that define the load-sorting characteristics of mechanical and resin bolt types to determine roof bolting specifications that will lead to objective comparisons between resin and conventional bolt types and yield useful data related to hole spacing and roof support characteristics. Creep properties for bolted joints were used in finite element analyses of sections of the White Pine Copper Co. mine that included analyses of bed separations in the roof and sloping faults. In situ experimental measurements were made of tension, compression, and bending of resin bolts by use of strain-gaged bolts. Evaluation of bolting effectiveness and comparisons of predicted and measured roof behavior are given. Volume I contains an introduction and detailed objectives of the report. Research done under contract H0230014 by Michigan Technological University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mining Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; 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 123(2)–81. Finite Element Analysis Applied to Resin and Mechanical Roof Bolting Systems for Strata Bound Deposits. Volume II. Final Report, by J. C. Gerdeen, G. L. Viegelahn, V. W. Snyder, P. M. Schwab, H. Schuyten, C. J. Wick, and T. J. Collison. Aug. 31, 1976. 48 pp. 18 figs. The purpose of this program was to find the relationships that define the load-sorting characteristics of mechanical and resin bolt types to determine roof bolting specifications that will lead to objective comparisons between resin and conventional bolt types and yield useful data related to hole spacing and roof support characteristics. Creep properties for bolted joints were used in finite element analyses of sections of the White Pine Copper Co. mine that included analyses of bed separation in the roof and sloping faults. In situ experimental measurements were made of tension, compression, and bending of resin bolts by use of strain-gaged bolts. Evaluations of bolting effectiveness and comparisons of predicted and measured roof behavior are given. Volume II contains a description of input data for computer program SAP-S. Research done under contract H0230014 by Michigan Technological University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mining Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; 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 123(3)–81. Finite Element Analysis Applied to Resin and Mechanical Roof Bolting Systems for Strata Bound Deposits. Volume III. Final Report, by J. C. Gerdeen, G. L. Viegelahn, V. W. Snyder, P. M. Schwab, H. Schuyten, C. J. Wick, and T. J. Collison. Aug. 31, 1976. 88 pp. 24 figs. The purpose of this program was to find the relationships that define the load-supporting characteristics of mechanical and resin bolt types to determine roof bolting specifications that will lead to objective comparisons between resin and conventional bolt types and yield useful data related to hole spacing and roof support characteristics. Creep properties for bolted joints were used in finite element analyses of sections of the White Pine Copper Co. mine that included analyses of bed separations in the roof and sloping faults. In situ experimental measurements were made of tension, compression, and bending of resin bolts by use of strain-gaged bolts. Evaluations of bolting effectiveness and comparisons of predicted and measured roof behavior are given. Volume III contains a study of the fully grouted resin roof bolt under traverse loading. Research done under contract H0230014 by Michigan Technological University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mining Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; 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 123(4)–81. Finite Element Analysis Applied to Resin and Mechanical Roof Bolting Systems for Strata Bound Deposits. Volume IV. Final Report, by J. C. Gerdeen, G. L. Viegelahn, V. W. Snyder, P. M. Schwab, H. Schuyten, C. J. Wick, and T. J. Collison. Aug. 31, 1976. 103 pp. 7 figs. The purpose of this program was to find the relationships that define the load-supporting characteristics of mechanical and resin bolt types to determine roof bolting specifications that will lead to objective comparisons between resin and conventional bolt types and yield useful data related to hole spacing and roof support characteristics. Creep properties for bolted joints were used in finite element analyses of sections of the White Pine Copper Co. mine that included analyses of bed separations in the roof and sloping faults. In situ experimental measurements were made of tension, compression, and bending of resin bolts by use of strain-gaged bolts. Evaluations of bolting effectiveness and comparisons of predicted and measured roof behavior are given. Volume IV contains appendix D, a listing of computer program SAP-S. Research done under contract H0230014 by Michigan Technological University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mining Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Administration, Beckley, W. Va.; 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 124(1)–81. Longwall Subsidence Case History Number 1: Northern Appalachian Coal Region, by Larry R. Powell. August 1981. 12 pp. 5 figs. As part of the Bureau of Mines effort to establish a comprehensive subsidence data base for subsidence technology development, subsidence and related data are being compiled for various mining, geological, and environmental situations. This report presents data for a longwall mining operation in the Northern Appalachian coal region. Vertical displacements and relative face positions are tabulated for 110 subsidence monuments. Measurements were taken 12 times during the 8 months it took to mine the panel. Brief physiographic and geological descriptions of the mining site are presented along with a general account of the mining and subsidence monitoring methods. Research done by the Bureau of Mines Twin Cities Research Center. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill.; 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 124(2)–81. Longwall Subsidence Case History Number 2: Northern Appalachian Coal Region, by Larry R. Powell. August 1981. 12 pp. 2 figs. As part of the Bureau of Mines effort to establish a comprehensive subsidence data base for subsidence technology development, subsidence and related data are being compiled for various mining, geological, and environmental situations. This report presents data for a longwall mining operation in the Northern Appalachian coal region. Vertical displacement and relative face positions are tabulated for 160 subsidence monuments. Measurements were taken 32 times during the 2 years it took to mine the 2 panels. Brief physiographic and geological descriptions of the mining site are presented along with a general account of the mining and subsidence monitoring methods. Research done by the Bureau of Mines Twin Cities Research Center. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill.; 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 125–81. Infrared Imaging Borehole Probe (Infrared Borehole Imaging Probe), by C. L. Davies and E. H. Izen. April 1980. 89 pp. 50 figs. A thermal imaging borehole probe was designed and fabricated to obtain thermal images, through smoke, of objects and people in underground mines. The effort was basically unsuccessful; electrical noise, and possibly thermal noise, interfered with the desired signals to the extent that spatial resolution in the images was unacceptable. Research done under contract H0377009 by Xerox Electro-Optical Systems. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mining Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; 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 126–81. Evaluation of Control and Protection Circuits, by E. C. Strycula and D. A. Paice. April 1981. 50 pp. 21 figs. Solid-state equipment offers a number of potential advantages in the coal mining industry. These advantages can only be realized, however, through careful and judicious design of the control and protection circuitry. Problems relating to the interaction of solid-state equipment on the electrical system and the special design considerations that apply to solid-state circuitry are examined. Design guidelines are provided for solid-state applications in the areas of (1) equipment operated from a dc trolley wire, (2) drive systems for surface mining equipment, (3) ac motor starters, and (4) electromagnetic interference. Research done under contract J0308035 by Westinghouse Electric Corp. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mining Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-105065; paper copy price code A03.

OFR 127–81. Surface Chemical Technology for Improved Wetting of Coal Dust, by Nathan Feldstein. February 1981. 50 pp. 11 figs. The wetting of coal dust by aqueous solutions of surface active agents (surfactants) has been studied. Thirty coals and typical surfactants were selected from typical classes of anionic, nonionic, and cationics for study. Of these three classes the practical use of cationics in aqueous solutions was eliminated because of the inherent negative Zeta potential charge of the representative coals. The wetting of the coals was examined by column flow, contact angle, and settling rate measurements. Results indicated that both anionic and nonionic surfactants are to be considered viable for use; low critical micelle concentration values are also preferred for the surfactants. Study of native waters showed substantial variation in properties, i.e., pH, calcium ion concentration, and conductance. pH variations were also noted to affect the effectiveness of selected surfactants. Combinations of nonionic and anionic surfactants have, in certain instances, produced synergistic enhancement in the coal wetting superior to the effectiveness of each surfactant alone. Research done under contract J0199050 by Surface Technology, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mining Safety and

Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–104654; paper copy price code A03.

OFR 128–81. Evaluation of Diesel Equipment Deployment in Underground Coal Mines. Volume III: Analysis of Diesel Deployment Schemes, by R. V. Ramani and G. W. Kenzy. Dec. 31, 1978. 202 pp. 39 figs. Procedures have been developed that permit determining in either existing or new mines the optimum diesel equipment deployment schemes and the effect of diesel exhaust on mine air quality. Specifically, the following areas are covered in the report: (1) Description of diesel deployment schemes in four underground coal mines that were visited. (2) Description of the analysis procedure to determine the number of shuttle cars required to maintain maximum theoretical continuous miner (or loader) production rates in typical room-and-pillar mining systems and the exhaust contamination resulting from the deployment of diesel-powered shuttle cars. (3) Sensitivity analyses to determine the effect of changes in input variables on production and contaminant concentrations are discussed. (4) Description of the analysis procedure to develop locomotive operating parameters and to assess production and the magnitude of diesel exhaust contamination. (5) Recommendations for extensions of this research to determine equipment duty cycles for diesel equipment, and to study the exhaust contamination of mine air on the basis of these duty cycles. Research done under grant G0166052 by Pennsylvania State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mining Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–122151; paper copy price code A10.

OFR 129(1)–81. Development of a Man and Supply Hoisting System for Underground Metal and Nonmetal Mines. Volume I. Final Report, by David J. Hoadley and Billy C. Brunelle. April 1981. 148 pp. 37 figs. This report describes the development and underground operation of a semiautomatic, raise climber, human and supply hoist system designed for stope access in underground metal and nonmetal mines. Demonstrated capabilities of the system include a 4,000-lb payload capacity, control from the traveling cage and from up to five remote stations, operating in vertical or inclined raises 5 ft in diameter and up to 300 ft in length, and a travel speed of 50 ft/min. The system has the capability of operating in crooked raises because the conveyance climbs two stationary wire ropes suspended down the raise. The drive unit is electrically powered with power and control signals supplied to the drive unit through an armored cable also suspended down the raise. The system has been designed for portability, ease of installation, and minimum raise development. The system can be installed by two workers in five shifts. This report provides a detailed description of the hoist design and its demonstrated performance in two mine applications. Research done under contract H0252068 by Foster-Miller Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–113366; paper copy price code A07.

OFR 129(2)–81. Development of a Man and Supply Hoisting System for Underground Metal and Nonmetal Mines. Operation and Maintenance Manual. Volume II. Final Report, by David J. Hoadley and Billy C. Brunelle. April 1981. 101 pp. 13 figs. This operation and maintenance manual for the man and supply hoist system applies a specific configuration designed to operate in a vertical raise bored shaft 5 ft in diameter. Guidance is provided by six pneumatic wheels mounted to the conveyance and bearing directly on the raise wall and by two sets of conveyance-mounted steel wheels that bear on a single raise-mounted 6-inch steel channel. The report gives a complete overall description of the system cross-referenced with maintenance procedures where appropriate. Research done under contract H0252068 by Foster-Miller Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; 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 130–81. Dust Control for Haul Roads, by Russel Bohn, Thomas Cuscino, Dennis Lane, Frank Pendleton, and Richard Hackney. February 1981. 146 pp. 4 figs. The purpose of this study was to evaluate the various techniques for mine roadway dust control. The evaluation included (1) the types of dust suppressants available, (2) the interaction of the dust suppressants with the properties of the roadway surface, and (3) the costs and performance measures of the predominantly used dust suppressants. Over 30 products were identified with a wide range of effectiveness depending largely on the properties of the roadbase, subsurface, and wearing surface. The effectiveness of a dust suppressant was also found to depend on the application and maintenance procedures employed. As a result of this investigation, five dust suppressants were identified as being predominant in the surface mining industry: petroleum resins, wetting agents, lignin sulfonate, water, and calcium chloride. An approximate cost-effective analysis, limited by lack of quantitative field performance data, showed that the five suppressants ranked in the order given, with water being one of the least cost effective. This report also presents an analysis of applicable Federal and State regulations. Research done under contract J0285015 by Midwest Research Institute. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mining Safety and Health Administration, Arling-

ton, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–116666; paper copy price code A07.

OFR 131–81. The Implementation of UHF Radio Communications and CCTV Monitoring Systems in a Room and Pillar Metal/Non-Metal Mine, by R. A. Isberg, H. Kramer, and D. A. Parrish. March 1981. 132 pp. 52 figs. This report describes the design and implementation of radio and closed-circuit television systems in the Black River room-and-pillar limestone mine near Butler, Pendleton County, Ky. Prior to designing the radio system, measurements of signal attenuation on 812 and 466 MHz were made in the slope tunnel and in the straight and level crosscuts in the mine. Two distributed antenna systems fed by two sets of base stations provide approximately 75 pct coverage of the mine. Passive reflectors were used for extending signals into intersecting crosscuts and two-way signal boosters will be used to extend signals to the perimeter and obstructed areas of the mine. Fourteen mine vehicles were equipped with mobile radios with digital identification, alarm, and status encoders. Fifteen portable transceivers also were used. Six closed-circuit television cameras provide surveillance of critical transfer points of the belt conveyor system, the loading dock at the base of the slope, and an ash disposal area in the mine. Two-way radio communication and closed-circuit television have saved considerable work hours, increased production, reduced maintenance costs, and enhanced safety. Research done under contract J0377044 by Comsul Ltd. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–116674; paper copy price code A07.

OFR 132–81. Model Demonstration of Drainage Structures for Safety of Mine Waste Impoundments, by Mark P. Zaitsoff and Chao-Lin Chiu. June 1981. 51 pp. 22 figs. The objective of this investigation was to study the design, construction, and testing of hydraulic models of culvert, decant, and open spillway systems that are typical drainage structures used for protecting mine waste embankments. Test results and products in the forms of graphs, tables, and film demonstrating the principles and factors that govern the function and performance of the three types of drainage structure are included. Research done under contract J0205014 by University of Pittsburgh. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mining Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; 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 133(1)–81. Energy Absorption Systems for Mine Cages. Final Report, Vol. 1. Free Fall Testing of Single Tooth Safety Dogs on Keruing Guides, by F. A. Penning, D. R. Sorensen, and D. W. Robertson. May 1980. 214 pp. 103 figs. A number of highly instrumented free-fall tests were performed on an arrestment system for a human cage in a vertical shaft. A single-tooth safety dog was used to stop on 4- by 6-in Keruing (Philippine mahogany) wet and dry wood guides. Twenty-seven free-fall tests were performed covering weights from 3½ to 10½ tons and hoisting velocities from 850 to 1,350 ft/min. Average g loads were measured from a low of 0.6 to a high of 3.4. The electronic instrumentation included piezoelectric and seismic mass accelerometers, strain gages on structural and mechanical elements, load cells in the guides, and distance measuring. Computer analysis was used to correlate with experimental measurements used to calculate stress. A statistical analysis gave no indication that the velocity or area affected the wood-crushing stress. The instrumentation revealed a chatter occurring during the stop that imposes loads much higher than the average g load, as shown by the accelerometers, strain gages, and load cells. Research done under contract H0282049 by Colorado School of Mines. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mining Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; 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 133(2)–81. Energy Absorption Systems for Mine Cages. Final Report, Vol. II. Study Energy Absorption Characteristics of a Pit Bottom Buffer, by F. A. Penning, M. H. Brinkmann, and D. W. Robertson. August 1980. 139 pp. 93 figs. An experimental and analytical investigation was conducted on a recoverable pit bottom buffer using a free-fall test tower. The four-sided buffer was constructed of reinforced rubber slabs loaded along their edge. A series of constant energy and maximum design velocity tests were conducted. Static testing of the buffer established the load-deformation behavior. Creep was evident during the loading and unloading cycle. Electronic instrumentation measured deceleration using four accelerometers; overall and intermediate movement was found from four displacement transducers, bending strains were recorded at four locations, and base reactions were measured by using four load cells. Data were recorded on tape and played back on a recording oscillograph. Symmetry of response and rebounds, when they occurred, were noted. From the displacement and load-time data, maximum decelerations were calculated by four methods and different assumptions. Good agreement was found from these approaches. A dynamic computer model was written for the response of the buffer. Displacement- and acceleration-time plots show close correspondence with experimental data for the 10 experiments. Data from accelerometers, displacement transducers, strain gages, and load cells are included. The computer program listing

and displacement- and acceleration-time plots are also presented. Research done under contract H0282049 by Colorado School of Mines. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mining Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; 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 134–81. Outcrop Barrier Design Guidelines for Appalachian Coal Mines, by Mary L. Pearson, Terje Preber, and Peter J. Conroy. Feb.6,1981. 167 pp. 51 figs. This report includes summaries of existing legislation pertaining to outcrop barriers and state-of-the-art survey of outcrop barrier designs and related mine closure techniques. Six sites were inspected in the field and are presented as case histories. The data analysis presented includes a computer-modeled seepage analysis, an overburden blow-out analysis, and a wedge stability analysis. The results of these analyses are interpreted to form recommendations for coal outcrop barriers that will minimize seepage and the potential for failure. Supplementary support and reinforcement alternatives are also discussed. Research done under contract J0395069 by Dames & Moore. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mining Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–113838; paper copy price code A08.

OFR 135–81. Cables for Face Equipment Standardization of Requirements. Final Report, by R. Stefanko, C. Bise, G. Luxbacher, and K. Katen. June 1. 1981. 49 pp. 6 figs. This paper covers the findings in three areas of research: cable protection, circuit breakers, and high-voltage cable couplers. Laboratory and analytical studies have been conducted in the three areas to determine proper circuit-breaker settings, cable sizes, and coupler performance. Also, an extensive field-monitoring program was established to relate in-mine experience to laboratory findings. Further, various pieces of equipment were designed for laboratory testing, particularly in the area of cable reeling and unreeling. Research done under contract H0377043 by Pennsylvania State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mining Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–113820; paper copy price code A03.

OFR 136–81. Upgrade Stench Fire Warning System—System Development and Prototype Tests, by Terry L. Muldoon, Ted Lewtas, and Thomas E. Gore. April 1981. 142 pp. 37 figs. This report describes the development and demonstration of an upgraded stench fire warning system for underground mines. Current systems release an ethyl mercaptan mixture into the compressed and/or ventilation air of a mine during an emergency. When smelling ethyl mercaptan, miners evacuate the mine according to predetermined plans. These systems, while simple, have problems with safety and reliability that can be overcome with the upgraded system. Thiophane, which is a different stench agent used in the upgraded system, is less toxic, less nauseating, and less corrosive than ethyl mercaptan. These features, and because thiophane does not react with iron oxides, make the upgraded system safer and more reliable. The system also uses a combination of two simple principles: a standpipe with pressure balancing to provide a constant head and a sized orifice to control the rate of release of the stench agent. The system enables mine operators to release the agent for a longer period, which provides better coverage and ensures that miners will not be exposed to potentially toxic concentrations of the stench agent. Research done under contract H0292002 by Foster-Miller Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; Mining Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–122128; paper copy price code A07.

OFR 137–81. Personal Samplers for CO, NO, and NO_2 in Air, by E. D. Palmes and C. Tomczyk. January 1980. 36 pp. A new type of personal sampler for quantitative estimation of atmospheric concentrations of contaminant gases was first reported from this laboratory in 1972. The sampler requires no pumps or flow regulators and employs instead the motion of the gas molecules themselves to furnish the power for sampling. Work was completed on development of a kit for the field determination of both NO_2 and NO. Detailed instructions for the preparation of the samplers and the use of the kit were supplied and attempts were made to adapt the same type of sampler to the measurement of SO_2 and CO. Both gas chromatographic and turbidimetric procedures for the final estimation of the SO_2 proved to be unsatisfactory. For CO no reagent was found that would react with sufficient rapidity with this gas to utilize the essential feature of the diffusion sampler, the maintenance of a diffusion gradient which is at least approximately numerically equal to the ambient concentration. A number of publications on use of the NO_2 sampler, both at occupational and community air pollution levels, have resulted from this work. Research done under grant G0177042 by New York University Medical Center. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mining Safety and Health Administration, Arlington, Va.; National

Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-123597; paper copy price code A03.

OFR 138–81. Placer Sampling and Related Bureau of Mines Activities on the Kenai Peninsula, Alaska, by Robert B. Hoekzema. September 1981. 28 pp. 2 figs. During 1979-80, the Bureau of Mines evaluated the mineral potential of approximately 1,120,000 acres in the northeastern portion of the Kenai Peninsula and northwestern Prince William Sound, Alaska. Systematic placer sampling identified that several previously nonproducing drainages in the east-central portion of the Kenai Peninsula and on the east side of Port Wells contain highly anomalous values of gold. This placer gold mineralization led to the identity of two potentially mineralized, northeasterly striking belts of limonite-stained pyrrhotite-bearing metasediments that are characterized by the presence of numerous felsic sills and dikes and sulfide-bearing quartz veins. The rivers, and the basins they drain, should be explored further for placer and lode gold deposits. Research done by Alaska Field Operations Center. Available for reference at the Office of the Director, Division of Land Assessment, Bureau of Mines, Washington, D.C.; Bureau of Mines facilities in Anchorage, Fairbanks, and Juneau, Alaska; 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 139–81. Development of Improved Detection Instruments for Toxic Gas Contaminants in Mining Atmospheres, by J. A. Kosek and A. H. Gruber. February 1981. 115 pp. 47 figs. Work has been carried out under a Bureau of Mines contract to develop and fabricate gas sensors for mining applications. Promising new instruments have been designed, developed, tested, and supplied to meet Bureau requirements. These instruments include prototype (1) remote-sensing, diffusion-type CO monitors for mine operation that can be operated in conjunction with a surface computer, (2) control modules for alternate in-mine readout of the remote diffusion type CO monitors, (3) personal CO diffusion-type dosimeters, and (4) personal NO diffusion-type dosimeters. In addition, retrofit modifications were made to update and optimize operation of CO and NO_2 direct-reading type detectors provided under a previous contract. Studies were conducted to evaluate and demonstrate the availability of stable, portable NO_2 calibration sources for NO_2 instrumentation. The use of selected, commercially available cylinder sources for NO_2 instrument calibration were recommended. Additional studies were also conducted to investigate the feasibility of instrumentation for rapidly monitoring CO, NO, and NO_2 in diesel exhaust. Research done under contract H0395132 by General Electric Co. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mining Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82-129578; paper copy price code A06.

OFR 140–81. Coal and Uranium Investigation of the Yukon Flats Cenozoic Basin, by James C. Barker. September 1981. 63 pp. 9 figs. The coal and uranium resource potential of the Western Yukon Flats was investigated by the Bureau of Mines during the 1978–79 field seasons. Previously, the mineral endowment of the area was largely unknown and there existed only partial 1:250,000-scale geologic reconnaissance mapping. The Yukon Flats is an extensively vegetated sedimentary basin of interior Alaska in which terrigenous sediments have been accumulating since Eocene (?) time. Preliminary evidence presented in this report suggests that sedimentation apparently has been taking place under climatic conditions typical of the mid-Tertiary at higher latitudes elsewhere. Conditions then were warm to paratropical and may have varied to rather hot and arid. Evidence includes relatively thick coal formations, the extensive occurrence of nonmarine evaporite minerals, undated but typical of continental arid saline lakes, stratiform tungsten enrichment, and fossil data that was previously reported. Research done by Alaska Field Operations Center. Available for reference at the Office of the Director, Division of Mineral Land Assessment, Bureau of Mines, Washington, D.C.; Bureau of Mines facilities in Anchorage, Fairbanks, and Juneau, Alaska; 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 141–81. Billings Glacier Molybdenum-Copper Occurrence, Whittier, Alaska, by Robert B. Hoekzema and Gary E. Sherman. 1981. 30 pp. 3 figs. A previously unreported occurrence of molybdenum and copper mineralization in a small granitic stock exposed at the toe of Billings Glacier, 5.5 miles northeast of Whittier, Alaska, was discovered and examined by the Bureau of Mines in July and August 1981. Molybdenite occurs as disseminated grains and crystalline clusters, up to 1½ inches across, apparently associated with hydrothermally altered portions and also along fractures in the granitic pluton. Molybdenite also occurs as disseminated grains in spheroidally weathering granitic xenoliths found in the pluton near its eastern contact. Minor pyrite and minor amounts of chalcopyrite are disseminated throughout marginal portions of the pluton. A high-grade sample of the mineralized granite contained 2,000 ppm Mo but other samples did not exceed 30 ppm. Copper did not exceed 90 ppm and generally was less than 50 ppm in samples of the stock analyzed. Research done by Alaska Field Operations Center. Available for reference at the Office of the Director, Division of Mineral Land Assessment, Bureau of Mines, Washington, D.C.; Bureau of Mines facilities in Anchorage, Fairbanks, and Juneau, Alaska; 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 142–81. Portable Remote Control Circuit Breaker System for Mine Trolleylines, by John F. Burr and Harry M. Dushac. June 1, 1978. 117 pp. 42 figs. This report describes the various stages of the development of a portable remote control circuit breaker system. The report presents (1) the details and problems involved with the movement of off-track mining equipment in an underground coal

mine, (2) a preliminary field test program, (3) details of the fabrication and field testing of the preliminary prototype remote control system, (4) the fabrication of the final prototype system, and (5) system features that include the ability to trip, reset, and adjust remote circuit breakers from a transmitter located on a mine locomotive. Research done under contract H0366029 by Consolidation Coal Co. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–128067; paper copy price code A06.

OFR 143–81. Investigation of a Copper Occurrence in the Rampart Diorites, by Mark M. McDermott, Jeffrey Y. Foley, and Dennis D. Southworth. 1981. 26 pp. 4 figs. During the 1976–79 field seasons, the Bureau of Mines made mineral evaluation studies of the trans-Alaska pipeline corridor for the Bureau of Land Management. Part of the work was done by the University of Alaska, who in 1977 reported a body of hornblende diorite in the Rampart Group south of Hess Creek in the Livengood quadrangle that locally contained as much as 10 pct sulfide. In 1979 the Bureau of Mines used a combination of geological, geophysical, and geochemical methods to evaluate the potential of this area for porphyry-type copper deposits. Low concentrations of copper were found as minor occurrences in small diorite dikes and sills. The low concentrations found and the low tonnages implied by this mode of occurrence suggest that the Rampart Group assemblage has little potential for porphyry-copper-type deposits. Research done by Alaska Field Operations Center. Available for reference at the Office of the Director, Division of Mineral Land Assessment, Bureau of Mines, Washington, D.C.; Bureau of Mines facilities in Anchorage, Fairbanks, and Juneau, Alaska; 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 144–81. Manganese Nodule Resource Data, Sea Scope Expedition, by R. H. Fewkes, W. D. McFarland, and R. K. Sorem. June 15, 1981. 230 pp. 10 figs. New information on possible resource value of sea floor manganese nodule deposits in the eastern North Pacific has been obtained by a study of records and collections of the 1972 Sea Scope Expedition. Nodule abundance (percent of sea floor covered) varies greatly, according to photographs from eight stations and data from other sources. All estimates considered reliable are plotted on a map of the region. Similar maps show the average content of Ni, Cu, Mn, and Co at 89 stations from which three or more nodules were analyzed. Variations in nodule metal content at each station are shown graphically in an appendix, where data on nodule sizes are also given. Results of new analyses of 420 nodules from 93 stations for Mn, Fe, Ni, Cu, Co, and Zn are listed in another appendix. Relatively high Ni + Cu content is restricted chiefly to four groups of stations in the equatorial region, where group averages are 1.86, 1.99, 2.47, and 2.55 weight-percent. Research done under grant G0284008 by Washington State University. Available for reference at Bureau of Mines facilities in Juneau, Alaska, Denver, Colo., Pittsburgh, Pa., and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–142571; paper copy price code A11.

OFR 145–81. Longwall Subsidence Case History Numbers 3 and 4. Northern Appalachian Coal Region, by Larry R. Powell. February 1981. 17 pp. 4 figs. As part of the Bureau of Mines effort to establish a comprehensive subsidence data base for subsidence technology development, subsidence and related data are being compiled for various mining, geological, and environmental situations. This publication presents data for two longwall mining operations in the Northern Appalachian Coal Region. Vertical displacements and relative face positions are tabulated for 104 subsidence monuments. Brief physiographic and geological descriptions of the mining sites are presented along with a general account of the mining and subsidence monitoring methods. Research done by Twin Cities Research Center. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., 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 146–81. Massive Sulfide Tailing Disposal Using the Thickened Discharge Method, by Gerald M. Bandholz. June 1981. 229 pp. 31 figs. This report discusses the advantages of using the thickened discharge method for massive sulfide tailing disposal. The thickened discharge method is described along with other methods of massive sulfide tailing disposal and cost comparisons are given. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Juneau, Alaska, Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; 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 147–81. Technological Investigations To Develop Design Criteria for the Optimum Size of Oil and Gas Well Blocks, by Kenneth Wardell, Peter Eynon, and Christopher Wardell. Feb. 8, 1980. 130 pp. 22 figs. This report presents criteria that have been developed to determine the optimum size of oil and gas well blocks. The criteria lead to the formation of well barrier pillars that are, of themselves, inherently stable and take account of variable mine roof and floor conditions. The criteria ensure that strains transmitted to well casings are within tolerable limits of specifications. The criteria cater for well barrier pillars in multiseam mining situations and where previous mining has taken place, maintains flexibility in being adaptable to local mine design situations. Research done under contract J0285010 by K. Wardell & Partners. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and

Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; 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 148–81. Airborne Dust From Taconite Tailings, by D. H. Yardley, W. D. Lacabanne, and R. C. Nelson. November 1980. 53 pp. 18 figs. The objective of this report was to evaluate a variety of dust suppressants to determine their effectiveness in mitigating dust from taconite tailings. Field test plots were established on taconite tailings and wind tunnel laboratory tests were conducted. The tests consisted of comparing treated and untreated samples at wind velocities of 40 mph using a weight-loss method and direct dust emission measurements. It was shown that the emission of fine dust from taconite tailings in the 4.5- to 0.85-micrometer range could be reduced by 99 pct using certain chemical suppressants. It was also shown that a straight water spray on coarse tailings reduced dust emission by 95 pct. Although eight different chemicals were tested, most of the tests were made using Coherex, ammonium lignin sufonate, and sodium silicate. These dust suppressants were used singly and in combination on almost 75 field test plots. The Coherex appears to provide the best results in terms of economics and durability. Wind tunnel tests on treated and untreated Cu-Ni tailings showed that applications of dust suppressants reduced fugitive fine dust by better than 99 pct. Research done under contract J0265055 by University of Minnesota. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mining Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–143173; paper copy price code A04.

OFR 149–81. Development of an Explosion Proof High Voltage Cable Connector, by H. E. Dresch. Feb. 5, 1981. 32 pp. The objective of this report was to design and construct a high-voltage, explosion-proof cable connector for use on underground coal mine drag cables. A connector was constructed with elastomeric phase insulators that provide insulation shielding throughout the connector length. The connector housing was made of flame-resistant cast polyurethane with no exposed metal components. Electrical and mechanical testing of the completed coupler resulted in satisfactorily meeting most of the design testing requirements. Research done under contract H0188068 by The Scott & Fetzer Co. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mining Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–142589; paper copy price code A03.

OFR 150–81. Demonstration of a Dust Control System for Boom-Type Roadheader, by Mackenzie Burnett, Robert J. Pokora, and Terry Muldoon. September 1981. 54 pp. 16 figs. This program was initiated by the Bureau of Mines to quantify the respirable dust problem caused by the use of roadheaders in underground metal-nonmetal mines with special emphasis on this problem in uranium mines. The objective was to develop methods or equipment to alleviate respirable dust and to implement a solution in a mine. Attempts to quantify the dust problem were made by a survey of MSHA records, a survey of State mine enforcement agencies, a survey of mine records, and dust measurements taken at two mines using roadheaders. The results are not conclusive because of limited and sometimes less than useful data; however, the study does indicate that a serious dust problem could and may exist. The report discusses the available data concerning respirable dust problems and presents a solution that can potentially help to solve the problem. The solution requires the use of blowing ventilation, onboard dust extraction at the source, filtration, and continued use of water sprays. Research done under contract J0199093 by Foster-Miller Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mining Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–143199; paper copy price code A04.

OFR 151–81. Evaluation and Demonstration of a New Post-Disaster EM Communication Technique for Mines, by M. P. Ristenbatt and E. K. Holland-Moritz. February 1981. 101 pp. 37 figs. The objective of this report was to quantitatively compare an existing emergency mine communication system with a proposed automated system that features extended signal processing and a novel signal. A new post-disaster system, intended to use through-the-earth EM propagation, was demonstrated at input signal-to-noise ratio (SNR) of −34 db. The system presently available requires an input SNR of + 6, and uses a human ear detector. The present work demonstrated coherent integration for the automated system in multiples of 17 seconds, up to 1,088 seconds (18 minutes). A repeating pseudorandom (or pseudonoise) signal is used that offers an ideal autocorrelation at the receiver matched-filter output. A novel decision-variable algorithm achieves the estimate of noise level by using those matched-filter output samples that occur between the signal autocorrelation peaks. Research done under contract J0199109 by University of Michigan. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; National Mine Health and Safety Academy, Beckley, W. Va.; and National Library of Natural Resources, U.S. Department of the Interior, Wash-

ington, D.C. Order ONLY from NTIS: PB 82–143181; paper copy price code A05.

OFR 152–81. Production Engineering, Development, and Demonstration of the Draft Power Sensor. Volume I, by H. Stanley Benson. November 1980. 60 pp. 26 figs. This report describes research conducted to improve the performance of and then further field test draft power sensor (DPS) equipment. DPS equipment enables a bulldozer operator to optimize a machine's work rate. Significant improvements were made in DPS hardware, and extended field testing was conducted at two working strip mines. The report documents the increase of bulldozer work production by greater than 20 percent while using the DPS compared with baseline work production without benefit of the DPS. Research done under contract H0292016 by Southwest Research Institute. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mining Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–143165; paper copy price code A04.

OFR 153–81. Technical and Economic Evaluation of Mine Closure Procedures. Final Report, by George Akens, John Metz, and Paul Bilzi. June 1980. 281 pp. 19 figs. The purpose of this report is to provide industry with a document to aid in the selection of a closure method and to aid government officials in evaluating closure methods that have been used in the past. The types of seals presently in use for numerous engineering environmental and economic parameters were evaluated. A survey of State and Federal regulations pertaining to mine closure is included. Numerous drawings are also included along with several case histories of mine closures. Research done under contract J0285030 by Skelly and Loy. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mining Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–136995; paper copy price code A13.

OFR 154–81. Develop Grounding Practices for Metal/Nonmetal Mines, by Wils L. Cooley and Herman W. Hill, Jr. Feb. 27, 1981. 235 pp. 64 figs. This report analyzes electrical accident data in the metal-nonmetal mining industry. Accidents are categorized to determine the root causes. Special attention is given to accidents associated with inadequate or defective grounding of mine power systems. Recommendations are made concerning proper grounding practice, especially for dredges and for quarries in hard rock or sand. The costs of instituting the recommended practices are estimated for model mine power systems which are based on field data obtained from 37 mines and several electrical contractors. The expected benefits of various suggested safety practices are also estimated. Research done under contract J0308025 by West Virginia University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–137308; paper copy price code A11.

OFR 155–81. Noise Control of a Mine Operated Rail Personnel Carrier. Volume II. Underground Evaluation, by A. G. Galaitsis and D. Andersen. July 1980. 35 pp. 18 figs. The two volumes of this report summarize the noise control work performed on a rail personnel carrier operated in coal mines. Volume I describes the aboveground work performed to identify the noise sources, design, fabricate, and install and evaluate the treatments through noise and vibration tests. Volume II describes the underground work conducted to determine the deterioration, if any, of the treatments when the vehicle was operated normally in a mine. There were no significant changes in the acoustical performance or mechanical integrity of the treatments at the end of a 3-month period. Research done under contract H0166090 by Bolt Beranek and Newman Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mining Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–137019; paper copy price code A03.

OFR 156–81. Water Handling Procedures for Reducing Acid Formation in Underground Coal Mines, by John R. Williams and Richard J. Keenan. Oct. 1, 1980. 106 pp. 17 figs. The treatment of acid mine drainage can amount to a considerable expense over the life of a mine where highly pyritic materials are present. Two possible options to reduce costs are reducing inflow to a mine or collecting and transporting the water once it has entered a mine to minimize its contact with acid-producing material. Planning the water-handling system should be part of the initial mine design. Adequate geologic and hydrologic data are necessary to avoid areas where high inflows may occur, or to plan for handling and treating the inflows. This report discusses several methods to reduce or prevent inflows, including surface and stream diversions, dewatering of aquifers, grouting and sealing, and leaving barrier pillars between adjacent mines. Mine closure and down-dip mining are also considered in reducing acid mine drainage formation. The design of water-handling systems in a mine is covered in detail. The system must be integrated throughout a mine. Methods of determining pump requirements and size, pipe sizing, and various types of acid mine

drainage treatment are discussed. Research done under contract J0199027 by Skelly and Loy. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mining Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–137324; paper copy price code A06.

OFR 157–81. Cable Handling in Surface Mines, by R. Marshall, C. Mertian, and R. Winkle. Sept. 19, 1980. 62 pp. 9 figs. Electrical trailing cable handling techniques and practices used in metal and nonmetal surface mines were investigated by obtaining information through visits to mine properties located in a variety of geological areas and climatic conditions. An analysis was made of all accidents related to cable handling that were cataloged by the Health Safety Analysis Center from 1978 through June 1980. Information was also collected from mine operators concerning near accidents and nonreported accidents. The results of this investigation were presented to the Bureau of Mines in an effort to outline recommended practices for cable handling in surface mines and to recommend additions and/or changes in the regulations now being enforced by the Mine Safety and Health Administration. These recommendations are also intended to assist the Bureau of Mines in evaluating the need for assisting mine operators in the areas of training and distribution of information related to material handling of trailing cables. Research done under contract J0395088 by Pincock, Allen & Holt, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–139346; paper copy price code A04.

OFR 158–81. Ground Fault and Overcurrent Protection Criteria for Coal Mine AC Distribution Systems, by John A. Kiefer and Jeffery L. Kohler. Oct. 31, 1980. 174 pp. 55 figs. Ground fault and overcurrent protection criteria for coal mine ac distribution systems were examined by authorization of the Bureau of Mines. The report begins with a literature review that discusses relaying topics including instrument transformers, ground fault pickup methods, static relaying, and comparison of relaying techniques. A chapter on ground fault relaying provides recommendations for maximum and minimum pickup levels as a function of maximum ground current and power system line-to-ground capacitance. Research in the area of phase overcurrent protection has resulted in a complete set of procedural recommendations for the selection and setting of overcurrent relays and current transformers, molded-case circuit breakers, and distribution system fuses in coal mine power systems. The final chapter discusses relay system maintenance and introduces a unique test set that is used to test the performance of relaying systems in coal mines. Research done under contract J0395035 by Ketron, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–137001; paper copy price code A08.

OFR 159–81. High Concentration Dust Monitor, by Pedro Lilienfeld. June 1981. 76 pp. 37 figs. The objective of this investigation was the development, design, fabrication, and testing of a portable, self-contained prototype monitoring instrument capable of detecting and measuring airborne coal dust levels as concentrations in the range of 20 to 500 g/m^3. The output of the high concentration dust monitor is essentially independent of particle size and composition, with a response time of 10 seconds. Direct concentration readout as well as internal memory or recording capabilities are incorporated in the device. The operation of the instrument is based on direct sensing of the mass concentration of airborne dust by air-path beta radiation attenuation. The monitor is battery operated and incorporates a microprocessor that controls periodic automatic zero referencing, executes the mass computations, records the data for subsequent playback, and performs internal diagnostic checks. The design emphasizes ruggedness, simplicity of operation, and adherence to intrinsic safety requirements. Research done under contract H0308010 by GCA Corp. Available for reference at Bureau of Mines facilities in Juneau, Alaska, Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mining Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–139320; paper copy price code A05.

OFR 160–81. Final Report—Evaluation of Coal-Mine Electrical-System Safety, by Lloyd A. Morley, Frederick C. Trutt, and Jeffery A. Kohler. June 1, 1981. 202 pp. 23 figs. This final report concludes the documentation under grant G0155003 and details research not covered under foregoing report volumes. The first chapter lists all other reports. The following chapters are divided into three major research tasks: Continuous Safety Monitoring Systems, Battery and Battery-Charging Safety, and Mine Power System Transients. The monitoring chapter discusses the prediction of power-system failures. The battery chapter details work on battery-box stresses, battery chargers, and the elimination of electrocutions. The final chapter covers transient instrumentation, distribution transients sources and suppression, and utilization transients on mine power systems. Research done under grant G0155003 by Pennsylvania State University. Available for reference at Bureau of Mines

facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mining Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–139338; paper copy price code A06.

OFR 161(1)–81. Control of Water Pollution From Surface Mining Operations. Volume I, by David R. Jessey, Judith M. Stangl, David H. Dike, Grant R. Brown, and Edward W. Schroeder. Jan. 31, 1981. 172 pp. 43 figs. Water pollution problems associated with surface metal-nonmetal mines throughout the United States were assessed. Three major problems were identified: acid mine drainage, toxic concentrations of heavy metals, and excessive sedimentation. Among the factors that affect the type and amount of pollutants generated at mine sites are hydrologic regime, geology, mineralogy, topography, climate, size of the mineralized area, and mining methods. Nine surface mines situated in different settings were visited and the pollution problems were studied. A detailed evaluation of the pollution problems at one mine indicated that a diversion system and treatment plant would be the most effective means of abatement for the existing water quality problems. Based on this study and three other porphyry copper mines with differing problems, a water management plan was conceived for a new source copper mine. Research done under contract J0199089 by Wapora, Inc., and Ketron, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mining Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–139304; paper copy price code A08.

OFR 161(2)–81. Control of Water Pollution From Surface Mining Operations. Volume II, by David R. Jessey, Judith M. Stangl, Alfred H. Hirsch, David H. Dike, Grant R. Brown, and Edward W. Schroeder. Jan. 31, 1981. 275 pp. 57 figs. Water pollution problems associated with surface metal-nonmetal mines throughout the United States were assessed. This work contains detailed reports on mines located in Morenci, Hayden, and Sauharita, Ariz.; Cobalt and Fernwood, Idaho; Spruce Pine, N.C.; Iron Mountain, Calif.; and DeLamar, Idaho-Oregon. Research done under contract J0199089 by Wapora, Inc., and Ketron, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mining Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–139312; paper copy price code A13.

OFR 162(1)–81. Interactive Mine-Power-System Analysis. Volume I, by Frederick C. Trutt, Lloyd A. Morley, and Richard A. Rivell. Jan. 31, 1981. 209 pp. 9 figs. This report is intended as a reference for personnel interested in the computer analysis of coal mine electrical power systems under either normal operating conditions or fault situations. The procedures developed are described and implementation considerations are discussed. Considerations for choosing a solution technique and some examples are included. During program development, strict attention was given to the inclusion of core and/or time-saving techniques such that these algorithms may be implemented on small or large computers. Program languages include FORTRAN IV for batch processing applications and APL or BASIC for interactive applications. Research done under contract J0199060 by Pennsylvania State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–138298; paper copy price code A10.

OFR 162(2)–81. Interactive Mine-Power-System Analysis· User's Manual. Volume II, by Richard A. Rivell, Frederick C. Trutt, and Lloyd A. Morley. Jan. 28, 1980. 239 pp. 13 figs. This user's manual is intended as a reference for personnel interested in the analysis of coal mine electrical power systems. The interactive procedures developed for this purpose are described and implementation considerations are discussed. Considerations for choosing a solution technique and some examples are included. Procedures available include Gauss-Seidel and Newton-Raphson iterative techniques for analysis of normal operation or balanced faults and a noniterative Z-bus technique for analysis of unbalanced or balanced faults. Research done under contract J0199060 by Pennsylvania State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Boulder City and Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., and Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–138306; paper copy price code A11.

OFR 163(1)–81. Microseismic Roof Fall Warning System Development. Field Trials and Commercial Prototype Fabrication. Volume I. Final Report, by Carl Fisher, Jr., and Ramie H. Thompson. May 30, 1980. 197 pp 68 figs. A microseismic roof fall warning system was field tested in western and eastern coal mines in the United States to better define the capabilities and limitations of the microseismic method in predicting roof fall. Microseismic event and energy type data were obtained and documented for 23 coal mine roof falls. Field test results indicate

that both the microseismic event and energy methods, as applied, have a high probability for successful application in a commercially practical roof fall warning system. Volume I contains details of the investigation. Research done under contract H0272009 by Integrated Sciences, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mining Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–137837; paper copy price code A09.

OFR 163(2)–81. Microseismic Roof Fall Warning System Development. Field Trials and Commercial Prototype Fabrication. Volume II. Appendix C: Coal Mine Data Collection Summary. Final Report, by Carl Fisher, Jr. May 30, 1980. 228 pp. 36 figs. A microseismic roof fall warning system was field tested in western and eastern coal mines in the United States to better define the capabilities and limitations of the microseismic method in predicting roof fall. Microseismic event and energy type data were obtained and documented for 23 coal mine roof falls. Field test results indicate that both the microseismic event and energy methods, as applied, have a high probability for successful application in a commercially practical roof fall warning system. Volume II summarizes the data collected. Research done under contract H0272009 by Integrated Sciences, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mining Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–137845; paper copy price code A11.

OFR 164–81. Development of Fuel Cell Gas Detection Instruments for Use in a Mine Atmosphere, by J. A. Kosek, A. B. LaConti, A. Goldstein, G. Schnakenberg, and E. Chilton. Mar. 23, 1979. 131 pp. 40 figs. The objective of this report was to develop instruments for detecting CO, NO, and NO_2 in a mine atmosphere using fuel cell technology. The approach was to optimize the fuel cell sensor configuration for the specific detection of CO, NO, and NO_2 in the presence of other mine gases utilizing recent advances in catalyst, electrode, and solid polymer electrolyte membrane technology. Parametric testing was conducted on three electrode sensor cells to define performance and life characteristics as a function of temperature, feed flow, and applied sensor voltage. Extended life testing was performed on sensor cell configurations exhibiting favorable characteristics. Reliable, efficient gas sampling and electronic control circuitry was fabricated for use with the sensor cells and integrated into devices to meet the performance and design specifications for portable, battery-operated, handheld direct-indicating gas detectors for use underground. Research done under contract H0357078 by General Electric Co. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mining Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–137316; paper copy price code A07.

OFR 165(1)–81. Evaluation of Environmental Factors Involved in Metallurgical Processes To Utilize Domestic Resources for Production of Alumina. Phase II Report: Assessment of Two Raw Material/Process Technology Options, by L. C. Tisdel, W. J. Roushey, A. G. Melcher, F. T. Davis, J. M. Link, and R. C. Barth. December 1979. 121 pp. 4 figs. This study provides information on the environmental factors of two options for production of alumina from kaolin clay raw material that were selected by the Bureau of Mines for further study from six raw material-process technology options considered in a previously issued report. The options under study are hydrochloric acid leaching using HCl gas-induced crystallization and nitric acid leaching. This study concentrates on the hydrochloric acid leaching option because it has been identified as having a better potential for commercial development. Included in the assessment are mining and transportation of ore, construction and operation of the process plant, disposal of process wastes, and land reclamation considerations. The primary information sources for the study included process feasibility studies, Reports of Investigations, Information Circulars, and nonpublished material provided by the Bureau of Mines. The results indicate that the hydrochloric acid leaching option exhibits the least potential for adverse environmental effects. Research done under contract J0275040 by Colorado School of Mines Research Institute. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–138264; paper copy price code A05.

OFR 165(2)–81. Evaluation of Environmental Factors Involved in Metallurgical Processes To Utilize Domestic Resources for Production of Alumina. Phase III Report: Environmental Impact Criteria for Evaluating Potential Pilot Plant Sites: Clay/Hydrochloric Acid Extraction-Gas Induced Crystallization Process, by L. C. Tisdel, A. G. Melcher, and G. M. Hermsen. March 1981. 50 pp. 3 figs. This study provides information on criteria for use in environmental evaluation of potential sites for a pilot plant where production of alumina from domestic clay resources would be investigated. The study was based on a preliminary design for a pilot plant utilizing a hydrochloric acid extraction-gas induced crystallization process. The pilot plant would cover approximately 30 acres and construction would take approximately 2 years with a work force of 200 to 225 employees. An operating period of approximately 3 years is projected employing 160 to 170 people. The expected scale of the pilot plant is such that significant impact on most environmental factors of current concern could occur. Thus,

selection of a suitable site would be an important part of the planning process for the project. The results indicate that, among the environmental evaluation criteria developed, those related to preventing or minimizing adverse impact on socioeconomic conditions and air and water quality are likely to be most pertinent in the selection of a suitable pilot plant site. Research done under contract J0275040 by Colorado School of Mines Research Institute. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–138272; paper copy price code A03.

OFR 166–81. Delineation of Geologic Roof Hazards in Selected Coal Beds in Eastern Kentucky With Landsat Imagery Studies in Eastern Kentucky and the Dunkard Basin, by David K. Hylbert. Nov. 14, 1980. 100 pp. 47 figs. This study investigated stratigraphic and structural causes of roof falls in room-and-pillar drift coal mines in nine mines in eastern Kentucky. A contract modification provided for remote sensing studies in the Dunkard Basin of West Virginia and Pennsylvania. Results of stratigraphic and structural studies of an earlier study were applied to several new mines. It was found that similar rock sequences contributed to unstable roof conditions. Structure contour and isopach maps were useful in projecting these trends together with fence diagrams. Using Landsat imagery, a direct relationship was found between lineament direction and the trends of rock jointing, roof fall zones, "snap top" zones, and sandstone channels. From 50 to 65 percent coincided with roof falls when lineament intersections were analyzed. Research done under contract J0188002 by Morehead State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mining Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–140336; paper copy price code A05.

OFR 167-81. Pre-Mining Identification of Hazards Associated With Coal Mine Roof Measures, by Ronald W. Stingelin, Jeffrey R. Kern, and Stephen L. Morgan. Mar. 30, 1979. 208 pp. 84 figs. The geology of the roof of the Pittsburgh coalbed was studied and mapped in nine contiguous counties containing the bulk of the remaining reserves of this coalbed in the northern Appalachian coal basin. Drill core records from Belmont and Monroe Counties, Ohio; Washington and Greene Counties, Pa.; and Ohio, Marshall, Wetzel, Monongalia, and Marion Counties, W. Va., provided the data for 12 computer-generated regional geologic variable maps. Four of these geologic variables were used to estimate the risk of potential roof falls by a methodological scheme developed during this study. A hazard zone risk map was developed showing a generalized regional trend of increasing risk from west to east across the basin. The accuracy of the mapping is primarily dependent on the density of the drill core records. Geologic feature maps and the hazard risk map in this report are reduced versions of the larger scale maps prepared for the Bureau of Mines as map folios. Research done under contract J0177038 by HRB-Singer, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; U.S. Department of Energy facilities in Carbondale, Ill., Pittsburgh, Pa., and Morgantown, W. Va.; Mining Safety and Health Administration, Arlington, Va.; National Mine Health and Safety Academy, Beckley, W. Va.; and Office of Surface Mining Library and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 82–140344; paper copy price code A10.

HANDBOOKS

The following publications can be obtained from—

Section of Publications
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4800 Forbes Avenue
Pittsburgh, Pa. 15213

HB 1–81. Application Notes: Mine Electric Power Systems, by Staff, Bureau of Mines. 1981. 83 pp. 63 figs. These application notes on mine electric power systems are based on work done under contract to the Bureau of Mines. The notes are intended to provide ready reference to mine maintenance engineers. The subject covered in the first notes are (1) the measurement of earth resistivity, (2) measurement of ground bed resistance, (3) cable fault location using time domain reflectometry instruments, (4) cable fault location, (5) common splicing errors and how to avoid them, and (6) learning from failed splices. Because this is an active area of research, the Bureau of Mines plans to issue new and updated notes and to distribute them to the holders of the original publication. Additional application notes will include electric transient suppression and additional items on trailing cable splicing.

HB 2–81. Guidelines for Carrier Phone Systems: Installation, Maintenance, and Improvement, by James C. Cawley. 1981. 69 pp. 24 figs. This Bureau of Mines Handbook describes the installation and maintenance of carrier phone systems in underground coal mines. Detailed information is also presented on specific ways to improve existing carrier phone systems.

PATENTS

The following patents were granted to the Bureau of Mines during the period January 1 to December 31, 1981. 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, were developed by Bureau scientists or under contracts with the Bureau. Application for the use of any of the patents should be made to the Division of General Law, Office of the Solicitor, U.S. Department of the Interior, Washington, D.C. 20240.

P 1–81. Extensometer Anchor. Charles Herman, III. U.S. Pat. 4,242,915, Jan. 6, 1981.

P 2–81. Method of In Situ Mining. Roger J. Morrell, William C. Larson, and Robert D. Schmidt. U.S. Pat. 4,249,777, Feb. 10, 1981.

P 3–81. Dust Controlling Method Using a Coal Cutter Bit. Wallace W. Roepke. U.S. Pat. 4,251,109, Feb. 17, 1981.

P 4–81. Impedance Measuring Method of and Apparatus for Detecting Escaping Leach Solution. Daryl R. Tweeton. U.S. Pat. 4,253,063, Feb. 24, 1981.

P 5–81. Link-Loc Chainless Haulage System. Paul J. Guay. U.S. Pat. 4,254,710, Mar. 10, 1981.

P 6–81. Copper Electrowinning and Cr^{+6} Reduction in Spent Etchants Using Porous Fixed Bed Coke Electrodes. David M. Soboroff and Hector O. McDonald. U.S. Pat. 4,256,557, Mar. 17, 1981.

P 7–81. Siliceous Adsorbent for Heavy Metals. Thomas G. Carnahan and Charles M. Flynn, Jr. U.S. Pat. 4,256,587, Mar. 17, 1981.

P 8–81. Preparation and Use of High Surface Area Transition Metal Catalysts. Gary B. Atkinson. U.S. Pat. 4,256,653, Mar. 17, 1981.

P 9–81. Leaching Agglomerated Gold-Silver Ores. Harold J. Heinen, Gene E. McClelland, and Roald E. Lindstrom. U.S. Pat. 4,256,705, Mar. 17, 1981.

P 10–81. Leaching Agglomerated Gold-Silver Ores. Harold J. Heinen, Gene E. McClelland, and Roald E. Lindstrom. U.S. Pat. 4,256,706, Mar. 17, 1981.

P 11–81. Selective Removal of Mercury From Cyanide Solutions. Charles M. Flynn, Jr., Thomas G. Carnahan, and Roald E. Lindstrom. U.S. Pat. 4,256,707, Mar. 17, 1981.

P 12–81. Process for Recovering Ni (II), Cu (II), and Co (II) From an Ammoniacal-Ammonium Sulfate Leach Liquor. Richard E. Siemens, David Nilsen, and Stanley C. Rhoads. U.S. Pat. 4,258,016, Mar. 24, 1981.

P 13–81. Recovery of Chromium From Scrap. Francis J. Hennion, John J. deBarbadillo, and Umar M. U. Ahmad. U.S. Pat. 4,259,296, Mar. 31, 1981.

P 14–81. Decomposition of $AlCl_3 \cdot 6H_2O$ in H_2 Atmosphere. Ishwarlal D. Shah. U.S. Pat. 4,259,311, Mar. 31, 1981.

P 15–81. Production of Alumina From Aluminum Nitrate Solutions. Barlane R. Eichbaum, Judith A. Eisele, and Donald J. Bauer. U.S. Pat. 4,260,589, Apr. 7, 1981.

P 16–81. Portable Airborne Droplet Impactor Sampler and Method. Lung Cheng and Warren G. Gross. U.S. Pat. 4,265,107, May 5, 1981.

P 17–81. Combined Rotating Bed Scrubber and Water Eliminator. Edward F. Divers. U.S. Pat. 4,266,829, May 12, 1981.

P 18–81. Auger Construction Providing Reduced Noise. Thomas J. Retka and Donald W. Schoen. U.S. Pat. 4,266,830, May 12, 1981.

P 19–81. Permeability Restoration and Lowering of Uranium Leakage From Leached Ore Beds. David C. Grant and Herbert A. Burgman. U.S. Pat. 4,270,802, June 2, 1981.

P 20–81. Automatic Feed and Rotational Speed Control System of a Hydraulic Motor Operated Drill. Michael O. Dressel. U.S. Pat. 4,271,914, June 9, 1981.

P 21–81. Electrowinning of Lead From H_2SiF_6 Solution. Ernest R. Cole, Jr., Agnes Y. Lee, and Danton L. Paulson. U.S. Pat. 4,272,340, June 9, 1981.

P 22–81. Ferric Leaching of Uranium Values From Lignite. Lawrence E. Schultze, Donald J. Bauer, and Michael T. Morimoto. U.S. Pat. 4,272,491, June 9, 1981.

P 23–81. Slideboard Device for Underground Mine Face Ventilation. Edward F. Divers and John C. LaScola. U.S. Pat. 4,282,802, Aug. 11, 1981.

P 24–81. Metal Hydride Actuation Device. Peter M. Golben. U.S. Pat. 4,282,931, Aug. 11, 1981.

P 25–81. Passive Explosion Barrier for Mines. Israel Liebman, John Corry, and Richard Pro. U.S. Pat. 4,284,144, Aug. 18, 1981.

P 26–81. Process of Electroplating a Platinum-Rhodium Alloy Coating. David R. Flinn and Cheryl L. Manger. U.S. Pat. 4,285,784, Aug. 25, 1981.

P 27–81. Recovery of Bismuth From Chloride Process Solutions. Charles M. Flynn, Jr., Thomas G. Carnahan, and Roald E. Lindstrom. U.S. Pat. 4,285,912, Aug. 25, 1981.

P 28–81. Recovery of Lithium From Low-Grade Ores. Charles F. Davidson. U.S. Pat. 4,285,914, Aug. 25, 1981.

P 29–81. High Surface Area Transition Metal Catalysts and Method of Preparing Same. Gary B. Atkinson, Larry J. Nicks, and Donald J. Bauer. U.S. Pat. 4,287,095, Sept. 1, 1981.

P 30–81. Sputtering Apparatus for Coating Elongated Tubes and Strips. Robert Blickensderfer. U.S. Pat. 4,290,877, Sept. 22, 1981.

P 31–81. Method For Clarifying Slimes. Sanaa E. Khalafalla and George W. Reimers. U.S. Pat. 4,295,971, Oct. 20, 1981.

P 32–81. Discriminating Circuit Breaker Protection System Direct Current Power Distribution Systems. Derek A. Paice and Alan B. Shimp. U.S. Pat. 4,296,450, Oct. 20, 1981.

P 33–81. Self-Contained Closed Circuit Breathing Apparatus Having a Balanced Breathing Resistance System. Thomas E. Bernard and Richard L. Stein. U.S. Pat. 4,299,216, Nov. 10, 1981.

P 34–81. Flexible Continuous Grout Filled Packer for Use With a Water Infusion System. Albert Sainato, Joseph Cervik, and Leonard J. Prosser, Jr. U.S. Pat. 4,300,631, Nov. 17, 1981.

P 35–81. Thorium Oxide-Containing Catalyst and Method of Preparing Same. Gary B. Atkinson, Larry J. Nicks, and Donald J. Bauer. U.S. Pat. 4,301,032, Nov. 17, 1981.

P 36–81. Method for Measuring the Ionic Activities in Water With a Differential Pressure Transducers. Nev A. Gokcen. U.S. Pat. 4,301,676, Nov. 24, 1981.

P 37–81. Open Surface Flotation Method. Dan M. Bass and Fun-Den Wang. U.S. Pat. 4,302,051, Nov. 24, 1981.

P 38–81. Mounting Block to Rotate Coal Cutter Bits. Wallace W. Roepke and Richard J. Wilson. U.S. Pat. 4,302,053, Nov. 24, 1981.

P 39–81. Triangular Shaped Cutting Head for Use With a Longwall Mining Machine. Wallace W. Roepke and Sterling J. Anderson. U.S. Pat. 4,303,277, Dec. 1, 1981.

P 40–81. Dewatering of Slimes. Annie G. Smelley, Robert W. Montgomery, and Bobby J. Hamner. U.S. Pat. 4,303,532, Dec. 1, 1981.

P 41–81. Production of Ferrochromium Alloys. John E. Pahlman and Sanaa E. Khalafalla. U.S. Pat. 4,306,905, Dec. 22, 1981.

P 42–81. Extraction of Metals From Mixtures of Oxides or Silicates. Charles F. Davidson. U.S. Pat. 4,307,066, Dec. 22, 1981.

P 43–81. System for Maintaining High Resonance During Sonic Agglomeration. James E. Dudgeon and Donald A. Stanley. U.S. Pat. 4,307,964, Dec. 29, 1981.

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B 671 ..... PB 82-127093
HB 1-81 ..... PB 81-231227
HB 2-81 ..... PB 82-128539
IC 8837 ..... PB 81-198020
IC 8838 ..... PB 80-157340
IC 8839 ..... PB 81-211468
IC 8840 ..... PB 81-211211
IC 8841 ..... PB 81-234510
IC 8842 ..... PB 81-227373
IC 8843 ..... PB 82-104399
IC 8844 ..... PB 81-226284
IC 8845 ..... PB 82-105123
IC 8846 ..... PB 82-120593
IC 8847 ..... PB 81-234502
IC 8848 ..... PB 82-135435
IC 8849 ..... PB 82-120601
IC 8850 ..... PB 82-120619
IC 8851 ..... PB 82-135443
IC 8852 ..... PB 82-104753
IC 8853 ..... PB 82-129446
IC 8854 ..... PB 82-158585
IC 8855 ..... PB 82-158577
IC 8856 ..... PB 82-178849
IC 8857 ..... PB 82-120155
IC 8858 ..... PB 82-135450
IC 8859 ..... PB 82-158726
IC 8860 ..... PB 82-142878
IC 8861 ..... PB 82-135468
IC 8865 ..... PB 82-146358
IC 8866 ..... PB 82-165655
IC 8867 ..... PB 82-195710
IC 8869 ..... PB 82-194085
MI Copper Industry .... PB 82-195041
MI U.S.S.R. ... PB 82-195033
MP Latin America .... PB 82-161001
MP Zimbabwe .. PB 82-129404
MY 1977, v. 2 .. PB 82-105248
MY 1977, v. 3 .. PB 82-208265
MY 1978-79, v. 2 ..... PB 81-211369
MY 1978-79, v. 3 ..... PB 81-246472
OFR 1-81 ..... PB 81-167512
OFR 2(1)-81 .. PB 81-168825
OFR 2(2)-81 .. PB 81-168833
OFR 2(3)-81 .. PB 81-168841
OFR 2-81 set .. PB 81-168817
OFR 3(1)-81 ... PB 81-168320
OFR 3(2)-81 ... PB 81-168338
OFR 3(3)-81 ... PB 81-168346
OFR 3-81 set .. PB 81-168312
OFR 4-81 ..... PB 81-171308
OFR 5-81 ..... PB 81-171324
OFR 6(1)-81 .. PB 81-166761
OFR 6(2)-81 .. PB 81-166779
OFR 6(3)-81 .. PB 81-166787
OFR 6(4)-81 .. PB 81-166795
OFR 6(5)-81 .. PB 81-166803
OFR 6-81 set .. PB 81-166753
OFR 7-81 ..... PB 81-179384
OFR 8-81 ..... PB 81-168361
OFR 9-81 ..... PB 81-178873
OFR 10-81 .... PB 81-179434
OFR 11-81 .... PB 81-183949
OFR 12-81 .... PB 81-181109
OFR 13-81 .... PB 81-167561
OFR 14-81 .... PB 81-166308
OFR 15-81 .... PB 81-163982
OFR 16-81 .... PB 81-166282
OFR 17-81 .... PB 81-167553
OFR 18-81 .... PB 81-166324
OFR 19-81 .... PB 81-166852
OFR 20-81 .... PB 81-166381
OFR 21(1)-81 .. PB 81-177909
OFR 21(2)-81 .. PB 81-177917
OFR 21(3)-81 .. PB 81-177925
OFR 21-81 set . PB 81-177891
OFR 22-81 .... PB 81-179418
OFR 23-81 .... PB 81-178881
OFR 24-81 .... PB 81-179400
OFR 25-81 .... PB 81-179426
OFR 30-81 .... PB 81-194466
OFR 31-81 .... PB 81-194474
OFR 33-81 .... PB 81-194540
OFR 34-81 .... PB 81-194482
OFR 35-81 .... PB 81-190241
OFR 38-81 .... PB 81-194961
OFR 39(1)-81 .. PB 81-194987
OFR 39(2)-81 .. PB 81-194995
OFR 40(1)-81 .. PB 81-194946
OFR 40(2)-81 .. PB 91-194953
OFR 41-81 ..... UCRL-52586
OFR 42-81 .... PB 81-195687
OFR 43-81 .... PB 81-194524
OFR 44-81 .... PB 81-194532
OFR 45-81 .... PB 81-194938
OFR 46(1)-81 .. PB 81-201592
OFR 46(2)-81 .. PB 81-201600
OFR 46(3)-81 .. PB 81-201618
OFR 46(4)-81 .. PB 81-201626
OFR 46(5)-81 .. PB 81-201634
OFR 46(6)-81 .. PB 81-201642
OFR 46(7)-81 .. PB 81-201659
OFR 46(8)-81 .. PB 81-201667
OFR 46-81 set . PB 81-201584
OFR 47-81 ..... ADA-082317
OFR 48-81 .... PB 81-215329
OFR 49-81 .... PB 81-214363
OFR 50-81 .... PB 81-214231
OFR 51-81 .... PB 81-214983
OFR 52-81 .... PB 81-214355
OFR 53-81 .... PB 81-217002
OFR 54-81 .... PB 81-215402
OFR 55-81 .... PB 81-215378
OFR 56-81 .... PB 81-215360
OFR 57-81 .... PB 81-214926
OFR 58-81 .... PB 81-214934
OFR 59-81 .... PB 81-214116
OFR 60-81 .... PB 81-215394
OFR 61-81 .... PB 81-215386
OFR 62-81 .... PB 81-214827
OFR 63-81 .... PB 81-214850
OFR 64-81 .... PB 81-214835
OFR 65-81 .... PB 81-214819
OFR 66-81 .... PB 81-214868
OFR 67-81 .... PB 81-214843
OFR 68(1)-81 .. PB 81-223729
OFR 68(2)-81 .. PB 81-223737
OFR 68(3)-81 .. PB 81-223745
OFR 68-81 set . PB 81-223711
OFR 70-81 .... PB 81-225906
OFR 71-81 .... PB 81-223380
OFR 72-81 .... PB 81-225898
OFR 73-81 .... PB 81-222515
OFR 76-81 .... PB 81-221988
OFR 77-81 .... PB 81-222358
OFR 78-81 .... PB 81-222374
OFR 79-81 .... PB 81-224412
OFR 80(1)-81 .. PB 81-221905
OFR 80(2)-81 .. PB 81-221913
OFR 84-81 .... PB 81-222739
OFR 85-81 .... PB 81-223414
OFR 86(1)-81 .. PB 81-225872
OFR 86(2)-81 .. PB 81-225880
OFR 87-81 .... PB 81-223406
OFR 90-81 .... PB 81-221996
OFR 91-81 .... PB 81-222218
OFR 92-81 .... PB 81-222325
OFR 93-81 .... PB 81-223331
OFR 94(1)-81 .. PB 81-222796
OFR 94(2)-81 .. PB 81-222804
OFR 94(3)-81 .. PB 81-222812
OFR 94(4)-81 .. PB 81-222820
OFR 94-81 set . PB 81-222788
OFR 96-81 .... PB 81-225799
OFR 98-81 .... PB 81-236762
OFR 99-81 .... PB 81-237646
OFR 100-81 ... PB 81-237414
OFR 101-81 ... PB 81-236754
OFR 102-81 ... PB 81-237455
OFR 103-81 ... PB 81-238354
OFR 104-81 ... PB 81-237471
OFR 105-81 ... PB 81-237406
OFR 106-81 ... PB 81-237372
OFR 108-81 ... PB 81-236770
OFR 109-81 ... PB 81-236796
OFR 110-81 ... PB 81-235475
OFR 111(1)-81 PB 81-236804
OFR 111(2)-81 PB 81-236812
OFR 112-81 .. PB 81-237513
OFR 114-81 ... PB 81-244501
OFR 115-81 ... PB 81-244493
OFR 116-81 ... PB 81-243248
OFR 118-81 ... PB 81-246480
OFR 119-81 ... PB 82-104340
OFR 120-81 ... PB 82-104357
OFR 121-81 ... PB 82-104936
OFR 122-81 ... PB 82-105164
OFR 126-81 ... PB 82-105065
OFR 127-81 ... PB 82-104654
OFR 128-81 ... PB 82-122151
OFR 129(1)-81 PB 82-113366
OFR 130-81 .. PB 82-116666
OFR 131-81 ... PB 82-116674
OFR 134-81 ... PB 82-113838
OFR 135-81 ... PB 82-113820

OFR 136–81	PB 82–122128	RI 8539	PB 82–106998
OFR 137–81	PB 82–123597	RI 8540	PB 81–230286
OFR 139–81	PB 82–129578	RI 8541	PB 82–104662
OFR 142–81	PB 82–128067	RI 8542	PB 81–231441
OFR 144–81	PB 82–142571	RI 8543	PB 81–231060
OFR 148–81	PB 82–143173	RI 8544	PB 81–231078
OFR 149–81	PB 82–142589	RI 8545	PB 81–226870
OFR 150–81	PB 82–143199	RI 8546	PB 81–231086
OFR 151–81	PB 82–143181	RI 8547	PB 82–104761
OFR 152–81	PB 82–143165	RI 8548	PB 81–231185
OFR 153–81	PB 82–136995	RI 8549	PB 82–104407
OFR 154–81	PB 82–137308	RI 8550	PB 82–115551
OFR 155–81	PB 82–137019	RI 8551	PB 82–128844
OFR 156–81	PB 82–137324	RI 8552	PB 82–128851
OFR 157–81	PB 82–139346	RI 8553	PB 82–107004
OFR 158–81	PB 82–137001	RI 8554	PB 82–120585
OFR 159–81	PB 82–139320	RI 8555	PB 82–104381
OFR 160–81	PB 82–139338	RI 8556	PB 82–135906
OFR 161(1)–81	PB 82–139304	RI 8557	PB 82–128547
OFR 161(2)–81	PB 82–139312	RI 8558	PB 82–128554
OFR 162(1)–81	PB 82–138298	RI 8559	PB 82–128562
OFR 162(2)–81	PB 82–138306	RI 8560	PB 82–129339
OFR 163(1)–81	PB 82–137837	RI 8561	PB 82–135484
OFR 163(2)–81	PB 82–137845	RI 8562	PB 82–135492
OFR 164–81	PB 82–137316	RI 8563	PB 82–135500
OFR 165(1)–81	PB 82–138264	RI 8564	PB 82–135518
OFR 165(2)–81	PB 82–138272	RI 8565	PB 82–135526
OFR 166–81	PB 82–140336	RI 8566	PB 82–129347
OFR 167–81	PB 82–140344	RI 8567	PB 82–145484
RI 8500	PB 81–233280	RI 8568	PB 82–135534
RI 8502	PB 81–180036	RI 8569	PB 82–135583
RI 8503	PB 81–179962	RI 8570	PB 82–145418
RI 8504	PB 81–181638	RI 8571	PB 82–135476
RI 8505	PB 81–180010	RI 8572	PB 82–135708
RI 8508	PB 81–227118	RI 8573	PB 82–135716
RI 8509	PB 81–180002	RI 8574	PB 82–145426
RI 8510	PB 81–180051	RI 8575	PB 82–145376
RI 8511	PB 81–196727	RI 8576	PB 82–176330
RI 8512	PB 81–198533	RI 8577	PB 82–142860
RI 8513	PB 81–196693	RI 8578	PB 82–179631
RI 8514	PB 81–197196	RI 8579	PB 82–159682
RI 8515	PB 81–196735	RI 8580	PB 82–158957
RI 8516	PB 81–198038	RI 8581	PB 82–160268
RI 8517	PB 81–197154	RI 8582	PB 82–159849
RI 8518	PB 81–197139	RI 8583	PB 82–158940
RI 8519	PB 81–197170	RI 8584	PB 82–158932
RI 8520	PB 81–198574	RI 8585	PB 82–160276
RI 8521	PB 81–197188	RI 8586	PB 82–175951
RI 8522	PB 81–197204	RI 8587	PB 82–158924
RI 8523	PB 81–226821	RI 8588	PB 82–177304
RI 8524	PB 81–227415	RI 8589	PB 82–179623
RI 8525	PB 81–226920	RI 8591	PB 82–135575
RI 8526	PB 81–226250	RI 8593	PB 82–177056
RI 8527	PB 81–226805	RI 8599	PB 82–158684
RI 8528	PB 81–227035	RI 8600	PB 82–158734
RI 8529	PB 82–104373	RI 8602	PB 82–141045
RI 8530	PB 81–198046	SP 1–81	PB 82–207473
RI 8531	PB 81–227365	SP 5–81	PB 81–233918
RI 8532	PB 81–227126	SP 6–81	PB 82–145400
RI 8533	PB 81–227357	SP 7–81	PB 82–142886
RI 8534	PB 81–232183	SP 8–81	PB 82–159971
RI 8535	PB 81–232407	TPR 111	PB 81–198509
RI 8536	PB 81–231458	TPR 112	PB 81–196701
RI 8537	PB 81–233314	TPR 113	PB 81–197931
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PB 82–145376. Geologic Factors in Predicting Coal Mine Roof-Rock Stability in the Upper Kittanning Coalbed, Somerset County, Pa., by A. T. Iannacchione, J. P. Ulery, D. M. Hyman, and F. E. Chase. 1981. 41 pp. 28 fiigs. (BuMines RI 8575. Paper copy, A03.)

PB 82–145400. List of Bureau of Mines Publciations and Articles, January 1, 1975, to December 31, 1979. With Subject and Author Index, compiled by S. Z. Palya. November 1981. 568 pp. (BuMines SP 6–81. Paper copy, A24.)

PB 82–145418. Process for Recovering Chromium and Other Metals From Superalloy Scrap, by J. J. deBarbadillo, J. K. Pargeter, and H. V. Makar.

1981. 73 pp. 27 figs. (BuMines RI 8570. Paper copy, A05.)

PB 82–145426. A Pyrometallurgical Method for Processing Ni-Cd Scrap Batteries, by D. A. Wilson and H. V. Makar. 1981. 14 pp. 3 figs. (BuMines RI 8574. Paper copy, A02.)

PB 82–145434. Evaluation of the Seismic System for Locating Trapped Miners, by J. Durkin and R. J. Greenfield. 1981. 55 pp. 33 figs. (BuMines RI 8567. Paper copy, A04.)

PB 82–146358. Underground Metal and Nonmetal Mine Fire Protection. Proceedings: Bureau of Mines Technology Transfer Seminars, Denver, Colo., Nov. 3, 1981, and St. Louis, Mo., Nov. 6, 1981, by Staff, Bureau of Mines. 1981. 151 pp. 93 figs. (BuMines IC 8865. Paper copy, A08.)

PB 82–158577. Uranium Mine Ventilation Costs, by R. C. Bates. 1981. 18 pp. 4 figs. (BuMines IC 8855. Paper copy, A02.)

PB 82–158585. Minerals and the Tokyo Round of the MTN, by D. E. Sullivan. 1981. 18 pp. (BuMines IC 8854. Paper copy, A02.)

PB 82–158684. Guidelines for Selecting Seismic Detectors for High-Resolution Applications, by C. M. Lepper. 1981. 37 pp. 24 figs. (BuMines RI 8599. Paper copy, A03.)

PB 82–158726. An Introduction to the Mine Inspection Data Analysis System (MIDAS), by W. F. Watts, Jr., R. L. Johnson, D. J. Donaven, and D. R. Parker. 1981. 41 pp. 11 figs. (BuMines IC 8859. Paper copy, A03.)

PB 82–158734. Electric Ignition of Lycopodium Powder in a Modified Hartmann Apparatus, by T. A. Kubala, F. J. Perzak, and E. L. Litchfield. 1981. 9 pp. 3 figs. (BuMines RI 8600. Paper copy, A02.)

PB 82–158924. Bentonite-Bonded Rammed Olivine and Zircon Molds for Titanium Casting, by R. K. Koch and J. M. Burrus. 1981. 40 pp. 15 figs. (BuMines RI 8587. Paper copy, A03.)

PB 82–158932. Laboratory Analysis of Pozzolan (Fly Ash) Concrete, by E. L. Phillips. 1981. 27 pp. 30 figs. (BuMines RI 8584. Paper copy, A03.)

PB 82–158940. Magnetic Properties of Alloys Containing Mischmetal, Cobalt, Copper, Iron, and Magnesium, by J. W. Walkiewicz, J. S. Winston, and M. M. Wong. 1981. 22 pp. 8 figs. (BuMines RI 8583. Paper copy, A03.)

PB 82–158957. Extracting Uranium From Carbonaceous Ores, by L. E. Schultze, D. J. Bauer, and M. T. Morimoto. 1981. 12 pp. 3 figs. (BuMines RI 8580. Paper copy, A02.)

PB 82–159682. Analysis of Pillar Stability on Steeply Pitching Seam Using the Finite Element Method, by N. P. Kripakov. 1981. 33 pp. 18 figs. (BuMines RI 8579. Paper copy, A03.)

PB 82–159849. Recovery of Principal Metal Values From Electrolytic Zinc Waste, by T. L. Hebble, V. R. Miller, and D. L. Paulson. 1981. 12 pp. 7 figs. (BuMines RI 8582. Paper copy, A02.)

PB 82–159971. Bureau of Mines Research 81. A Summary of Significant Results in Mineral Technology and Economics, compiled by J. R. Pederson. 1981. 148 pp. 118 figs. (BuMines SP 8-81. Paper copy, A08.)

PB 82–160268. Fine Coal-Refuse Slurry Dewatering, by R. R. Backer and R. A. Busch. 1981. 24 pp. 11 figs. (BuMines RI 8581. Paper copy, A02.)

PB 82–160276. Monitoring Ground Movements Near Caving Stopes—Methods and Measurements, by L. A. Panek and W. J. Tesch. 1981. 117 pp. 63 figs. (BuMines RI 8585. Paper copy, A06.)

PB 82–161001. Mineral Industries of Latin America, by O. Martino, D. Hyde, and P. Velasco. 1981. 116 pp. 32 figs. (BuMines MP. Paper copy, A07.)

PB 82–165655. Ergonomics—Human Factors in Mining. Proceedings: Bureau of Mines Technology Transfer Seminars, Pittsburgh, Pa., December 3, 1981, St. Louis, Mo., December 10, 1981, and Denver, Colo., December 15, 1981, compiled by Staff, Pittsburgh Research Center. 1981. 167 pp. 17 figs. (BuMines IC 8866. Paper copy, A08.)

PB 82–175951. Monitoring Submicrometer Particles in Sealed Fire Areas, by C. D. Litton, M. Hertzberg, A. L. Furno, and J. M. Kuchta. 1981. 20 pp. 12 figs. (BuMines RI 8586. Paper copy, A03.)

PB 82–176330. Fluorine and Uranium in Phosphate Rock Processing and Waste Materials, by B. W. Haynes, G. W. Kramer, and J. A. Jolly. 1981. 23 pp. 3 figs. (BuMines RI 8576. Paper copy, A02.)

PB 82–177056. Hydrogen Chloride Sparging Crystallization of Aluminum Chloride Hexahydrate, by D. E. Shanks, J. A. Eisele, and D. J. Bauer. 1981. 15 pp. 13 figs. (BuMines RI 8593. Paper copy, A02.)

PB 82–177304. Electrochemical Determination of Gibbs Energies of Formation of Cobalt and Nickel Sulfides, by S. C. Schaefer. 1981. 18 pp. 6 figs. (BuMines RI 8588. Paper copy, A02.)

PB 82–178849. Analyses of Natural Gases, 1980, by B. J. Moore. 1981. 236 pp. 1 fig. (BuMines IC 8856. Paper copy, A11.)

PB 82–179623. Recycling of Waste Magnesite-Chrome Refractories From Copper Smelting Furnaces, by A. V. Petty, Jr., and E. Martin. 1981. 18 pp. 7 figs. (BuMines RI 8589. Paper copy, A02.)

PB 82–179631. A Method for Determining Helium in Water, by P. W. Holland. 1981. 17 pp. 4 figs. (BuMines RI 8578. Paper copy, A02.)

PB 82–194085. Critical and Strategic Minerals in Alaska. Cobalt, the Platinum-Group Metals, and Chromite, by J. C. Barker, J. C. Still, T. C. Mowatt,

and J. J. Mulligan. 1981. 8 pp. 3 figs. (BuMines IC 8869. Paper copy, A02.)

PB 82–195033. The Nonfuel Mineral Outlook for the U.S.S.R. Through 1990, by J. S. Grichar, R. Levine, and L. Nahai. 1981. 17 pp. (BuMines MI. Paper copy, A02.)

PB 82–195041. The U.S. Copper Industry: Problems, Issues, and Outlook, by L. J. Sousa. 1981. 86 pp. 9 figs. (BuMines MI. Paper copy, A05.)

PB 82–195710. Borehole Shear Tester: Equipment and Technique, by K. Y. Haramy. 1981. 25 pp. 21 figs. (BuMines IC 8867. Paper copy, A02.)

PB 82–207473. Bureau of Mines Research 80. A Summary of Significant Results in Mineral Technology and Economics, compiled by J. D. Burket. 1981. 135 pp. 65 figs. (BuMines SP 1–81. Paper copy, A07.)

PB 82–208265. Minerals Yearbook 1977. Volume III. Area Reports: International, by Staff, Bureau of Mines. 1981. 83 ch. 1243 pp. (BuMines MY 1977, v. 3. Paper copy, A99.)

UCRL–52586. Analytical Modeling of Coal Mine Roof Behavior, by R. T. Langland. October 1978. 99 pp. 73 figs. (BuMines OFR 41–81. Paper copy, A05.)

ARTICLES IN OUTSIDE PUBLICATIONS

OP 1–81. Fire-Fighting Mini, by Donald N. H. Chi and Henry E. Perlee. Datamation Mag., September 1980, pp. 217–220. Research computer systems usually begin by filling several critical needs and then expand as demand develops among other groups in the laboratory. This paper describes the computer network used by the Bureau of Mines at the Pittsburgh Research Center in conducting and overseeing research related to health and safety in mines and in mine environmental technology.

OP 2–81. Preventing Frictional Ignitions, by Welby G. Courtney. Coal Min. & Proc. J., v. 8, No. 1, January 1981, pp. 48–58. This article reviews the history of frictional ignitions in U.S. Coal mining operations, laboratory studies of the problem, and specific remedial measures that can be implemented by mine operators to alleviate the frictional ignition problems.

OP 3–81. Health and Safety, by Robert Marovelli. Compress. Air (subarticle in Coal's Future: The Experts' Views), v. 85, No. 10, October 1980, pp. 14–15. Since the oil embargo of 1974, there has been less growth in the demand and consumption of coal than previously forecasted. Concern about the importation of oil brought a strong move toward increasing the consumption of coal during 1974–77, and a large amount of coal mining equipment was sold. But the mining producers overbought equipment, and the slackening-off of the market has produced a significant amount of unused equipment. This article discusses how this slackening-off of the market has affected the coal industry and the advantages and disadvantages of expanding the coal industry in the United States.

OP 4–81. Cobalt: A Strategic and Critical Resource for Industrialized Nations, Supplied by Developing Nations, by Scott F. Sibley. Natural Resources Forum, United Nations, v. 4, No. 4, October 1980, pp. 403–413. In 1978, the world cobalt market was abruptly thrust into a state of great uncertainty, with soaring prices, limited supply, and accelerating demand. A critical shortage threatened to develop but never really materialized. However, this situation dramatized Western nations' vulnerability to supply disruption. A number of factors, including limited natural occurrence, unfavorable market conditions, and accelerating demand for cobalt, combined to bring about these unstable conditions.

OP 5–81. Field Stress Corrosion Tests in Brine Environments of the Salton Sea Known Geothermal Resource Area, by J. P. Carter and S. D. Cramer. Mater. Performance, v. 19, No. 9, 1980, pp. 13–16. Corrosion research is being conducted by the Federal Bureau of Mines to determine suitable construction materials for geothermal resource recovery plants. As part of this research, a 30-day stress corrosion test was conducted at the Salton Sea Known Geothermal Resource Area on seven iron- and nickel-base alloys in four brine and steam process streams using wellhead brine from geothermal well Magmamax 1. The tests showed transgranular cracking of AISI 316L stainless steel and intergranular and transgranular cracking of AISI 430 stainless steel in all four process streams. E-Brite 26–1 exhibited intergranular and transgranular cracking in three of the four process streams. Carbon steel, Inconel 625, and Hastelloys G and C-276 show no evidence of stress corrosion cracking.

OP 6–81. Coal Liquefaction, by Franklin D. Cooper. Encyclopedia of Energy, McGraw-Hill Book Co., Inc., New York, 2d ed., 1980, pp. 136–139. This article discusses four direct-liquefaction processes, two indirect-liquefaction processes, and developing third-generation processes. Also discussed are production constraints, prospects and issues, hydrogen for liquefaction processes, costs, and modifications of second-generation direct liquefaction processes.

OP 7–81. Corrosion in Geothermal Brines of the Salton Sea Known Geothermal Resource Area, by S. D. Cramer and J. P. Carter. Geothermal Scaling and Corrosion, ed. by L. A. Casper and T. R. Pinchback, ASTM STP 717, 1980, pp. 113–141. Corrosion research is being conducted by the Bureau of Mines to determine suitable construction materials for geothermal resource recovery plants. High chromium-molybdenum iron-base alloys, nickel- and titanium-base alloys, and titanium-zirconium-molybdenum alloy exhibited good resistance to general, crevice, pitting, and weld corrosion and stress corrosion cracking in laboratory tests in deaerated brines of the Salton Sea Known Geothemal Resource Area (KGRA) type at 232° C and in brine containing dissolved carbon dioxide and methane. Only titanium-base alloys were resistant to corrosion in oxygenated Salton Sea KGRA-type brine. Copper adversely affected the resistance to general corrosion of low-alloy steels in deaerated brine, whereas chromium, nickel, silicon, and titanium improved it. Carbon steel, type 4130 steel, and types 410 and 430 stainless steels exhibited poor corrosion resistance in field tests in five brine and steam process streams produced from geothermal well Magmamax 1. These alloys were highly susceptible to pitting and crevice corrosion. General corrosion rates were high for carbon and type 4130 steels.

OP 8–81. Eastern Cement Kiln Dust Characterization, by B. W. Haynes, S. L. Law, and J. A. Jolly. Met. Soc., AIME, TMS Paper Selection A81–39, February 1981, 10 pp. Cement kiln dust (CKD) is a waste product that accumulates at the rate of 12 million tons per year in the United States. In proposed hazardous waste guidelines in 1978, the Environmental Protection Agency (EPA) placed CKD in the "Special Wastes" category pending more information on the composition, characteristics, and degree of hazard posed by this waste. In 1980, the Special Wastes category was removed, but a 3-year study of the hazard potential of CKD has been proposed by EPA. An exploratory evaluation of the resource recovery potential and environmental effects of the metals present in the dust has been underway during this period at the Bureau of Mines Avondale Research Center. Results of the first phase of this research—CKD from the east coast—will be discussed including major, minor, and trace element concentrations; mineralogy; iron chromatographic

and thermal information; and EPA hazardous waste leach test results.

OP 9–81. Surface Subsidence Due to Underground Longwall Mining in the Northern Appalachian Coal Field, by K. K. Kohli, S. S. Peng, and R. E. Thill. Pres. at SME-AIME Ann. Meeting, Las Vegas, Nev,, Feb. 24–28, 1980. SME Preprint 80–53, 8 pp. Since the adoption of the Surface Mining Reclamation and Control Act of 1977 there has been a sudden rise in demand on guidelines for minimizing surface subsidence and its associated structural damages. A 10-month survey resulted in a collection of surface subsidence surveys that was conducted by coal companies in the Northern Appalachian coal field over the past 20 years. This paper presents the preliminary results of the longwall subsidence data.

OP 10–81. Vibration and Air Blast Noise From Surface Coal Mine Blasting, by Patrick Linehan and John F. Wiss. Pres. at SME-AIME Fall Meeting and Exhibition, Minneapolis, Minn., Oct. 22–24, 1980, SME Preprint 80–336, 6 pp. Vibration and air blast noise from blasting were evaluated during a research program sponsored by the Bureau of Mines. Blast variables were studied using small-scale model tests to evaluate specific variables as well as interactive effects, followed by experiments with production blasts at the surface coal mines. Experimental data showed that the primary variables affecting the ground vibration amplitude are the charge weight per delay and the length of the delay interval. Blast variables with a significant affect on the overpressure amplitude include the charge weight per delay, the length of the delay, burden and spacing, stemming amount and type, direction of initiation, charge depth, and amount of detonating cord and cover.

OP 11–81. Dust Control Systems, by John N. Murphy. Proc. 3d Ann. Min. Institute, University of Alabama, Apr. 15–17, 1980, 30 pp. This paper presents an overview of the Bureau of Mines Respirable Dust Control Program. Completed and ongoing developments in the areas of dust generation, ventilation, scrubbers, personal protection, and instrumentation are discussed.

OP 12–81. Damage to Residential Structures From Surface Mine Blasting, by David E. Siskind. Pres. at SME-AIME Fall Meeting and Exhibition, Minneapolis, Minn., Oct. 22–24, 1980, SME Preprint 80–362, 17 pp. The Bureau of Mines has studied the problem of cracking in residential structure walls from vibrations produced by blasting in surface mines. Direct observations were made of blasting damage consisting primarily of cosmetic cracking in plaster and gypsum board walls. Measurements of structure response and also application of the response spectra analysis single-degree-of-freedom model were used to quantify the frequency dependence of the safe level criteria. An overall summary analysis was performed and data obtained from nine previous studies, including the three analyzed earlier by the Bureau for Bulletin 656 published in 1971. Separate analysis of the high- and low-frequency damage cases, structural response, and two types of construction resulted in the establishment of safe vibration levels ranging from 12 mm/sec to 50 mm/sec (0.5 in/sec to 2.0 in/sec).

OP 13–81. Hypothetical Mine Models and Input-Output Requirements for Copper-Nickel Mining in Minnesota, by David L. Veith. Pres. at SME-AIME Fall Meeting and Exhibition, Minneapolis, Minn., Oct. 22–24, 1980, SME Preprint 80–330, 21 pp. As the basis for the State of Minnesota's Regional Copper-Nickel Study environmental evaluation, hypothetical mine models were developed ranging in ore capacity from 5.35 to 2.00 x 10^6 mtpy. Open pit and underground mining operations were defined utilizing conventional methods of ore extraction. Processing of the copper-nickel sulfide material involved conventional bulk flotation of the valuable minerals, with maximum water recycle and tailing disposal. Flash smelting and electrolytic refining of the concentrate resulted in 0.10 x 10^6 mtpy copper plus nickel metal, plus associated cobalt and precious metals. Variations in model parameters allowed environmental trade-offs to be identified.

OP 14–81. Seepage Through Partially Saturated Soils Below a Uranium Tailings Pond, by E. G. Zahl and G. L. Bloomsburg. Proc. 1st Internat. Conf. on Uranium Mine Waste Disposal, Vancouver, British Columbia, Canada, May 19–21, 1980; American Institute of Mining, Metallurgical, and Petroleum Engineers, Inc., New York, ch. 30, December 1980, pp. 445–455. A finite-element computer program, UNSAT2, that simulates unsaturated flow is described and applied to a tailings pond near East Gas Hills, Wyo. Information necessary to run the program are tables of relative conductivity versus moisture content and capillary pressure versus moisture; porosity and saturated conductivity; and initial pressures, boundary conditions, and spatial coordinates for each nodal point. A 10-year simulation is made of the tailings pond based on existing field data and assumptions and interpolations where field data are lacking. The final phreatic surfaces through the cross section are similar but higher than measured values, probably due to limitations in assigning boundary conditions. UNSAT2 program results simulate actual conditions much better than saturated flow analysis. Limitations of applying the program to typical tailings ponds are lack of historical data, cost, and difficulty in obtaining representative data to determine relative conductivity—capillary pressure—moisture content relationships, and assigning realistic boundary conditions compatible with the program. Further work on the program could make it an effective method of analyzing flow beneath new, properly instrumented, tailings ponds.

OP 15–81. An Overview of Materials and Corrosion in Geothermal Systems, by J. P. Carter, S. D. Cramer, and R. K. Conrad. Pres. at Energy-Sources Technol. Conf. and Exhibition, New Orleans, La., Feb. 3–7, 1980 (pub. in Materials and Corrosion Problems in Energy Systems, ed. by W. J. Lochmann and M. Indig), pp. 17-1—17-10. For the past several years the Bureau of Mines has been involved in the development of the geothermal mineral resources of the Imperial Valley, Calif. The brines produced from geothermal reservoirs in this area are extremely corrosive. Furthermore, the brines readily form complex scales during processing that complicate the corrosion process and interfere with process operations. This paper presents examples of corrosion and materials problems encountered at some of the major geothermal systems presently being developed.

OP 16–81. Infrared Pyrometers for Measuring Dust Explosion Temperatures, by K. L. Cashdollar and M. Hertzberg. Modern Utilization of Infrared Technol. VI, SPIE, v. 253, 1980, pp. 254–260. This paper describes the design of two infrared optical

pyrometers used to study dust explosions. One is a six-wavelength pyrometer that can measure both dust particle temperature and gas temperature by observing continuum and gas band emission in the 1- to 5-μm infrared region using PbSe detectors. The second pyrometer measures particle continuum emission in the 0.8- to 1.0-μm region of the near infrared using Si detectors. Temperature data are presented for both laboratory- and full-scale mine explosions.

OP 17–81. The Corrosion Behavior of Niobium in Hydrochloric Acid Solutions, by B. S. Covino, Jr., J. P. Carter, and S. D. Cramer. Corrosion, v. 36, No. 10, October 1980, pp. 554–558. Studies to better understand the corrosion behavior of niobium in hydrochloric acid solutions have been conducted as part of the Bureau of Mines effort to conserve mineral resources in the United States. A study of the general corrosion behavior of niobium as a function of acid concentration, time, oxygen, and added ferric ion is reported. Weight loss (corrosion) tests were performed in air saturated (agitated and static) and helium saturated (agitated) hydrochloric acid solutions ranging from 1*N* to 10*N* at temperatures from 35° to 100° C and exposures up to 60 days. The 30-day corrosion rates ranged from 0.0 μm/y in 35° C air saturated (agitated) 1*N* HCl to 230 μm/y in air saturated (static) 9.8*N* HCl at 85° C. Although the corrosion rates decreased rapidly for times up to 30 days, the rates for 30 and 60 days were essentially identical. The presence of air did not affect the corrosion rate of niobium, while the presence of only 70 ppm of ferric ion reduced the corrosion rate in most air saturated 5*N* and 10*N* HCl solutions.

OP 18–81. An Overview of Sulfur-Extended Asphalt Usage, by W. C. McBee, T. A. Sullivan, and D. Saylak. Pres. at FAA Eastern Region Airport Eng. Seminar, Hershey, Pa., Mar. 3, 1980; pub. in Asphalt Pavement Construction: New Materials and Techniques, ed. by J. A. Scherocman, ASTM STP 724, pp. 39–63. Interest in the use of sulfur in highway pavement construction has been stimulated by unpredictable increases in cost and by uncertainty as to the future availability of asphalt cement as a result of the current "energy squeeze." As a consequence, bid prices for asphalt cement, which have almost tripled over the past 3 years, are expected to rise even more. Recent studies and experimental field tests have shown that sulfur can, under certain circumstances, replace as much as 35 vol-pct of the asphalt cement used in asphaltic concrete mixes. The unique properties of sulfur, both alone and when blended with asphalt, have also shown potential for use in recycling old bituminous pavements. This paper attempts to put into perspective the state-of-the-art in design, preparation, placement, and performance evaluation of sulfur-extended asphalt (SEA) pavement mixtures. Various methods of binder preparation are discussed and, where possible, compared on the basis of their physical and engineering properties. The status of three domestic experimental field trials utilizing these methods is reviewed. The potential use of SEA binder to recycle old bituminous pavements is also presented. Theoretical in-service performance predictions of SEA pavement materials are compared with conventional asphalt cement on the basis of their rutting potential, resistance to cracking, slope variance, and serviceability index. Finally, recommendations for future work are discussed.

OP 19–81. Electrochemical Determination of Thermodynamic Properties of Molybdenite (MoS_2), by S. C. Schaefer and N. A. Gokcen. High Temp. Sci., v. 12, 1980, pp. 267–276. As part of the Bureau of Mines effort to provide thermodynamic data for the advancement of mineral technology, thermodynamic properties of molybdenite (MoS_2) were determined with high-temperature galvanic cells employing stabilized zirconia as the electrolyte.

OP 20–81. Recovery of Molybdenum and Rhenium From Concentrates by an Electrooxidation-Solvent Extraction—Carbon Adsorption Technique, by B. J. Scheiner and D. L. Pool. Pres. at Internat. Cong., Inst. Min. Eng., Santiago, Chile, Nov. 23–29, 1980; Anales Congr. Cincuentenario Min. Cobres Porfidicos, v. 2, pp. 122–148. The Bureau of Mines has demonstrated an electrooxidation-solvent extraction-carbon adsorption technique for recovering molybdenum and rhenium from offgrade concentrates in a process research unit (PRU) operating at a feed rate of 3.4 to 4.7 lb of concentrate per hour. The flow sequence consists of metal values by electrooxidation, liquid-solid separation by thickening, acidification and chlorate ion removal by sulfur dioxide treatment, solvent extraction to concentrate the molybdenum and rhenium, separation of molybdenum and rhenium by carbon adsorption, and metal recovery by crystallization. Molybdenum and rhenium were recovered as ammonium paramolybdate and ammonium perrhenate. Based on PRU results, an industrial-sized cell was constructed and tested for extraction of metal values from offgrade molybdenite concentrates.

OP 21–81. Dewatering of Thickened Phosphate Clay Waste From Disposal Ponds, by B. J. Scheiner and A. G. Smelley. Pres. at AIME Ann. Meeting, Chicago, Ill., Feb. 21–26, 1981, TMS Paper Selection A81–6, 9 pp. The Bureau of Mines, as part of its mission to effect pollution abatement, conducted research to develop a technique for dewatering phosphate clay waste from disposal ponds. Phosphate clay waste was dewatered from 11.8 pct to greater than 20 pct solids using 0.53 lb of polyethylene oxide (PEO) per ton of dry solids. Dewatering was accomplished by mixing the clay waste with PEO and treating the resulting flocs on a static screen followed by further treatment on a rotating trommel screen. Discharge from the trommel screen, when placed in a column 23 inches in diameter and 11 feet in height, continued to dewater to greater than 28 pct solids in 90 days.

OP 22–81. Methanol Synthesis Catalysts From Thorium-Copper Intermetallics. Preparation and Evaluation, by Elizabeth G. Baglin, Gary B. Atkinson, and Larry J. Nicks. I&EC Prod. Res. and Develop., v. 20, No. 1, March 1981, pp. 87–90. Bureau of Mines research into the use of intermetallic compounds as catalytic materials has shown catalysts prepared from binary alloys of copper and thorium to be active for the synthesis of methanol from carbon monoxide and hydrogen. Activation of the alloys resulted in oxidation of the thorium yielding high surface area catalysts containing copper interspersed on thoria. For example, catalysts prepared from $ThCu_x$ alloys by air oxidation at 400° C had surface areas as high as 35 m^2/g and produced up to 6.7 times as much methanol as a traditional $Cu/ZnO/Al_2O_3$ catalyst from 16 H_2:CO synthesis gas in a continuous-flow microreactor at 280° C and 60 atm pressure. Standard inlet space velocity was 31,000 h^{-1}.

OP 23–81. A Drop Impact Sampler, by Lung Cheng and Warren G. Cross. Environ. Sci. Technol., v. 15, No. 4, April 1981, pp. 459–463. The drop impact sampler developed by the Bureau of Mines is based on the stain technique for measuring airborne drops. The stain technique requires a calibration curve to relate stain and drop diameters at a known impact velocity, usually the terminal value. However, physical constraints limit sampler location, making it difficult to attain the terminal value and thereby introducing complications; extrapolation of a calibration curve based on the spherical quiescent model to large drops results in an erroneously large diameter. The new sampler eliminates these difficulties and makes it possible to determine rates of depositions and spatial concentrations. The sampler can measure drop diameters ranging from 0.005 to 2.5 mm and is suitable for water sprays, raindrops, and carry-over drops such as from cooling towers. Laboratory tests have shown that the sampler is reliable, rugged, lightweight, and easy to use.

OP 24–81. Direct Flotation of Potash From Insoluble-Slime-Bearing Sylvinite and Carnallite Ores, by Donald G. Foot, Jr., and Jerry L. Huiatt. Pres. at AIME Ann. Meeting, Chicago, Ill., Feb. 22–26, 1981, SME Preprint 81–74, 8 pp. The Bureau of Mines devised a direct flotation method for treating low-grade carnallite ($KCl\text{-}MgCl_2 \cdot 6H_2O$) and sylvinite (a mixture of KCl and NaCl) ores characterized by a high content of water-insoluble impurities. The procedure consists of (1) flocculation-depression of the insoluble slimes, (2) decomposition leach (carnallite only), (3) potash rougher, cleaner, and recleaner flotation, and (4) final product leaching. The technique eleminates the necessity of removing the water-insoluble slimes by mechanical or flotation desliming. Laboratory results demonstrated that the direct flotation procedure, when compared with conventional techniques, yielded equivalent or improved flotation results with equal or less reagent consumptions. The direct flotation method recovered 81.6 pct of the solid-phase KCl from carnallite ore and 79.7 pct of the KCl from sylvinite ore in final products containing 60.5 pct and 60.9 pct K_2O. A flowsheet incorporating the described flotation procedure is presented.

OP 25–81. Biogeochemistry of Acid Mine Drainage and a Method to Control Acid Formation, by R. L. P. Kleinmann, D. A. Crerar, and R. R. Pacelli. Min. Eng., v. 33, No. 3, March 1981, pp. 300–305. A bacterium, *Thiobacillus ferrooxidans*, is of prime importance in the formation of acid drainage from pyritic material. Above pH 4.5, *T. ferrooxidans* increases initial acidification; below pH 4.5, it allows acidification to continue by oxidizing Fe^{2+}. Below a pH of approximately 2.5, the activity of Fe^{3+} is significant and results in steady-state cycling between oxidation of pyrite by Fe^{3+} and bacterial oxidation of Fe^{2+}. Laboratory and field tests demonstrate that inhibition of *T. ferrooxidans* by controlled release of anionic detergents can inexpensively reduce pyrite oxidation and acid formation.

OP 26–81. Computer Program To Aid in Adjusting Particle Size Distribution, by Arthur V. Petty, Jr., and D. B. Nevin. Am. Ceram. Soc. Bull., v. 60, No. 4, April 1981, pp. 506–507. Numerous situations in which particle size must be matched to a predetermined distribution or the distribution of a sample must otherwise be altered. Normally, this alteration requires screening the entire sample into various mesh sizes and recombining to form the desired distribution, or using extensive and time-consuming iterative calculations. A computer program to aid in these calculations was developed by the Bureau of Mines for use on a basic processing system. The program determines the quantity of material that must be added to a sample to adjust its size distribution to approximate that of a standard. Operating in an interactive mode, the program will accept up to 20 size fractions as input or will use a standard $\sqrt{2}$ distribution, depending on input commands. Also required as input are the particle size distributions of the standard and the sample to be adjused, the limit of error on the adjustments, and the mass (in grams) of the sample to be prepared.

OP 27–81. Platinum-Group Minerals in Alluvial Deposits, by J. Sjoberg and J. M. Gomes. Pres. at Precious Metals Conf., Reno, Nev., Nov. 17–20, 1980; pub. in California Geol., v. 34, No. 5, May 1981, pp 91–98. The Bureau of Mines is investigating the recovery of byproduct heavy minerals from California sand and gravel deposits as a means of more effectively utilizing these mineral resources. In one phase of the study different platinum-group metal (PGM) minerals are being identified to determine if variations in their geograhical distribution exist. Platinum-group mineral concentrates were recovered containing up to 1,000 oz/ton PGM. More than 20 PGM minerals were identified by SEM/microprobe analysis of samples from 12 areas of northern and central California. Major minerals identified were ferroplatinum, sperrylite, and osmiridium. Several mineral phases not previously reported in the literature as occurring naturally were tentatively identified. There are indications of the existence of variations in the geographical distribution of the major PGM minerals. The history, occurrence, geology, and uses of the platinum-group metals are discussed.

OP 28–81. Regeneration of Waste Chromic Acid Etching Solutions in an Industrial-Scale Research Unit, by L. C. George, D. M. Soboroff, and A. A. Cochran. Proc. 3d EPA/AES Conf. on Advanced Pollution Control for the Metal Finishing Industry, Kissimmee, Fla., Apr. 14–16, 1980; v. EPA-600, No. 2–81–028, February 1981, pp. 33–36. Substantial amounts of chromium are lost in various surface-finishing operations and pollution problems are created when spent solutions containing hexavalent chromium and sulfuric acid are discarded. Laboratory research has shown that these spent etching solutions can be regenerated in a diaphragm cell. When the spent solution is placed in the anode chamber, most of the Cr^{3+}, produced during etching operations, is oxidized to Cr^{6+}. Impurity metals dissolved during the etching operation are transferred to the catholyte. When waste brass etchants are treated, about one-third of the copper and zinc is removed. The energy consumption is less than 9 kwhr/kg of sodium dichromate regenerated. Similar results are obtained with spent printed-circuit-board etchants and rinse waters from plastic etching operations. An industrial-scale research unit capable of oxidizing up to 0.5 kg/hr of trivalent chromium has been operated to demonstrate the viability of the recycling techniques. Regenerated brass etchants evaluated by two companies equaled or exceeded the performance of fresh etchants.

OP 29–81. State-of-the-Art Guideline Manual for Design, Quality Control, and Construction of Sulfur-Extended-Asphalt (SEA) Pavements, by W. C. McBee, T. A. Sullivan, and J. O. Izatt. Fed. Highway Admin., U.S. Dept. Trans., FHWA-IP-80-14, August 1980, 52 pp. Interest in the use of sulfur in highway pavement construction has been stimulated by unpredictable increases in cost and the relative uncertainty as to the future availability of asphalt cement (A/C) along with the potential surplus of sulfur in the near future. These events have led to the development of a new binder: a sulfur-extended-asphalt (SEA) binder. This new binder replaces some of the asphalt with sulfur in conventional asphalt paving plants. The mix material can be transported, laid, and compacted with standard paving equipment. Studies of SEA pavements indicate that their properties are comparable and in some cases may prove to be superior to those of conventional asphalt pavements. The manual presents state-of-the-art guidelines for design, quality control, safety factors, and construction of these newly developed pavements. A nonproprietary, direct mixing method and four proprietary methods of producing the SEA mixtures are described.

OP 30–81. Role of Sulphur in SEA Pavements, by W. C. McBee, P. A. Romans, T. A. Sullivan, and R. R. Uhde. Pres. at Sulphur-81 Internat. Conf., Calgary, Alberta, Canada, May 25, 1981; pub. in Sulphur Res. & Develop., v. 4, pp. 5–12. As part of the Bureau of Mines Sulfur Utilization Program, paving materials were developed in which sulfur replaced up to 35 pct of the asphalt binder volume. These sulfur-extended asphalt (SEA) materials, along with those developed by private concerns, have been used to construct experimental highways in 20 States. Very little information has been obtained on the behavior of the materials during in-service aging. The sulfur microstructural features of core samples obtained from highways constructed using all existing SEA technologies are described. In addition, the activation energy for diffusion and solubility limits of sulfur in asphalt were determined for a typical paving asphalt. A mechanism for nucleation and growth of crystalline sulfur in the pavement is presented and related to the structure developed in the material.

OP 31–81. Dewatering of Coal-Clay Waste Using Polyethylene Oxide as a Flocculant, by B. J. Scheiner, Annie G. Smelley, and Jalna Zatko. Proc. Progress in the Dewatering of Fine Particles Conf., University of Alabama, Apr. 1–2, 1981, 20 pp. The Bureau of Mines is developing a dewatering technique for coal-clay wastes. The technique consists of mixing coal-clay waste with the flocculant polyethylene oxide (PEO) and dewatering the resulting flocs on a hydrosieve screen followed by further dewatering on a rotary trommel screen. Coal-clay waste slimes containing from 7 to 28 weight-percent solids have been consolidated up to 50 weight-percent solids using about 0.5 lb of PEO per ton of dry solids.

OP 32–81. Application of a Dewatering Technique to Industrial Wastes, by Annie G. Smelley and B. J. Scheiner. Proc. Progress in the Dewatering of Fine Particles Conf., University of Alabama, Apr. 1–2, 1981, 13 pp. In research conducted as part of its mission to effect pollution abatement, the Bureau of Mines has developed a specialized flocculation dewatering technique that may have wide application in the disposal of industrial wastes. This method allows for reuse of water previously lost with the wastes, eliminates or reduces the need for storage ponds, and facilitates recovery of mineral values. The flocculants used are high molecular weight polymers such as polyethylene oxide and polyacrylamides that can form strong, tough flocs with the wastes.

OP 33–81. Effect of Ion Exchange on Dewatering Phosphate Clay Waste With Polyethylene Oxide, by D. A. Stanley, P. M. Brown, and B. J. Scheiner. Proc. Progress in the Dewatering of Fine Particles Conf., University of Alabama, Apr. 1–2, 1981, 14 pp. As part of its mission to provide technology to assure a continuing supply of minerals, the Bureau of Mines conducted research to obtain a better understanding of how clays are flocculated by polyethylene oxide (PEO). The Bureau is presently developing a dewatering technique in which PEO is used to flocculate phosphatic clay waste and the resulting flocs dewatered on static and rotary screens. During the field testing of this technique, a clay waste was encountered that could not be dewatered readily. Studies indicated that the clay contained trace amounts of sulfides and that a portion of the exchange ions on the clay were probably hydrogen ions. Replacement of the exchange ions with calcium ions and agitation of the clay to oxidize the sulfides reduced the PEO requirements, which resulted in the clay being readily dewatered in both laboratory and large-scale field tests.

OP 34–81. The Limits of Flammability of Pulverized Coals and Other Dusts, by Martin Hertzberg, Kenneth L. Cashdollar, and Charles P. Lazzara. Proc. 18th Internat. Symp. on Combustion, Ontario, Canada, Aug. 9, 1980; The Combustion Institute, 1981, pp. 717–729. The limits of flammability of pulverized coals and other dusts were measured in a 7.8-liter system that provided accurate control of the significant experimental variables. The data are consistent, reproducible, and reliable, and the system is recommended as the standard for dust flammability studies.

OP 35–81. Inhibition of Acid Mine Drainage Formation: The Role of Insoluble Iron Compounds, by John W. Nebgen, William H. Engelmann, and Douglas F. Weatherman. Pres. at Inst. Environ, Sci. Ann. Meeting, Philadelphia, Pa., May 11–14, 1980; pub. in J. Environ. Sci., v. 24, No. 3, May-June 1981, pp. 23–27 This paper contains findings and conclusions from a 2-year study concerning chemical agents for the inhibition of acid mine drainage (AMD) formation. Three materials containing pyrite were evaluated in detail, but only one was a strong producer of AMD. Analysis of the experimental results strongly suggest that the rate at which pyrite is oxidized can be lowered substantially if the iron products from pyrite oxidation are kept insoluble. Analysis of the data does not distinguish between the lack of availability of soluble ferric ion as an oxidant or the exclusion of air by a ferric oxide coating. Either mechanism is compatible with the experimental data. Thus, methods to keep aqueous ferric ion minimized, for example, through insolubilization or maintaining high Fe^{++}/Fe^{+++} ratios, appear to be important in the chemical inhibition of AMD formation.

OP 36–81. Estimating Mine Pillar Strength From Compression Tests, by L. A. Panek. Trans. Soc. Min. Eng., AIME, v. 268, 1981, pp. 1749–1761. Using an approach based on the theory of similitude, a general equation and related concepts were developed

that provide new insights to an old problem. The load-bearing capacity (strength) of a square, rectangular, or cylindrical prism of a brittle material such as rock, coal, or concrete is expressed as the mathematical product of a size effect, a shape effect, and a function of the mechanical properties (deformability, cleat-joint spacing, and friction) of the pillar, roof, and floor materials. Through an application of multivariate statistical analysis, the results of assorted tests (laboratory and in situ) and observations of failed pillars can be combined into a fundamental scaling equation, which provides a unified, consistent approach to the estimation of mine pillar strength. The form of the equation is sufficiently general to be able to incorporate refinements in the characterization of the structural parameters, as they become available through future analysis and experimentation. Analysis of the published test data suggests that pillar compressive strength (per unit of area) is proportional to the cube root of the pillar width, and that the height effect can be described as the superimposing of a variable size effect (characteristic of the material) on the constant width effect.

OP 37–81. Prereduction and Melting of Domestic Chormites, by Ralph H. Nafziger, Phillip E. Sanker, Jack E. Tress, and Robert A. McCune. Proc. 38th Electric Furnace Conf., Iron and Steel Soc., AIME, Pittsburgh, Pa., Dec. 11–12, 1980, pp. 27–45. The Bureau of Mines has prereduced domestic chromites to provide a suitable charge material for the production of ferrochromium in an electric arc furnace. As part of the Bureau's goal to economically and efficiently recover metal values from domestic resources, this investigation has shown that prereduction of domestic chromites increases productivity and decreases electric energy consumption, compared with results where unreduced materials were used. Approximately 75 pct chromium metallization and 75 pct 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 pct were obtained when a metallurgical-grade chromite was prereduced. Satusfactory ferrochromium for the production of stainless steel was produced in an electric arc furnace from all of the prereduced materials.

OP 38–81. Deformation and Cracking of a Concrete-Lined Tunnel in a Rock Mass Subjected to a Changing State of Strain, by Louis A. Panek. Proc. 22d U.S. Symp. on Rock Mechanics, Cambridge, Mass., June 29-July 2, 1981, pp. 328–334. As part of an investigation of ground movements around a zone of caving ground, measurements were made of the deformation of a 90-meter length of mine tunnel. The tunnel lay astride the path of an approaching caved zone 64 meters wide, which eventually undermined the tunnel. The approach of the caving zone caused the rock mass around the tunnel to expand laterally and downward toward the cave, resulting in a gradual sinking of a portion of the tunnel and distortion of the tunnel section, which led to the fracturing of the concrete lining. Longitudinal extension and bending of the axis of the tunnel were measured, as well as the distortion of the tunnel cross section, using extensometers and tiltmeters of simple design. The approach was to monitor basic deformation components that could be conveniently measured by mine personnel, making maximum use of off-the-shelf hardware, to show that definitive data can be generated thereby. Especially notable was the demonstrated capability to determine from a triangular configuration of cross tunnel extensometer measurements the principal directions of deformation within the surrounding rock mass. By increasing the number of gage points from 2 to 3, three times as much information is obtained as by measuring roof-to-floor convergence.

OP 39–81. Effects of High Pressure, High Temperature Steam-Containing Environments on Alumina Refractory Concretes, by Leon Y. Sadler III, Nancy S. Raymon, Kenneth H. Ivey, and Hendrik Heystek. Am. Ceram. Soc. Bull., v. 60, No 7, July 1981, pp. 703–706. This paper describes results obtained in a study of the response of alumina-based refractory concretes to coal dry-ash gasifier environments. The investigations were designed to determine the relationship between observed refractory property changes after exposure to dry-ash gasifier environments and variables such as exposure temperature, steam partial pressure, gas velocity, aggregated and cement composition, and the presence of alkalis. Both commercially available and laboratory-formulated refractory concrete compositions, ranging from 45 to 95 pct alumina and containing low, intermediate, and high-purity calcium aluminate cements were studied. The refractories were exposed to environments at pressures ranging from 2.9 to 7.0 MPa (400 to 1,000 psig) and at temperatures ranging from 760° to 1,000° C. In some exposures, alkalis were introduced into the exposure environment. The steam-induced volatilization and vapor-phase transport of silica from the refractories under a variety of conditions were also studied.

OP 40–81. Smoke Characteristics of Coal-Lined Tunnel Fires, by Kenneth L. Cashdollar, Joseph M. Singer, Calvin K. Lee, and Charles D. Litton. Fire and Mater., v. 5, No. 2, 1981, pp. 47–51. Characteristics of smoke particulates generated from a coal fire in a ventilated model tunnel were investigated by laser optical transmission and by electron microscopy. Average particle diameter and mass concentration of the smoke were determined as a function of the temperature and stoichiometry of the coal tunnel fire. Smoke particle sizes ranged from 0.2 to 0.9 μm, with larger particle sizes associated with higher smoke concentrations. These coal smoke data are relevant to several aspects of underground mine safety including the development and location of smoke detection instruments, the understanding of the fire (toxic fume) hazards, and the development of new fire protection and control techniques.

OP 41–81. Potential Production Capacity of Metallurgical Coke, by Franklin D. Cooper. Iron and Steel Eng., v. 58, No. 9, September 1981, pp. 52–57. A method for determining the annual potential production capacity (ppc) for captive blast furnace coke is described together with examples relating battery age to productivity, time, and worker hour distributions for coke-oven operations and production costs. Based on a practical best fit combination of known operating variables involving more than 140 captive oven batteries, the study shows that the U.S. steel industry currently has blast furnace coke ppc equivalent to about 62 to 64 million tons annually of coke-related finished steel shipments.

OP 42–81. Bureau of Mines New Stopping Designs—An Update, by Edward D. Thimons and Fred N. Kissell. Min. Cong. J., v. 67, No. 7, July 1981, pp 1–4. Conventional stoppings of concrete block or

wood walls covered with mortar-type sealants, urethane foams, or heavy brattice cloth work well in many mining applications, but the time and cost of constructing and maintaining them can make them impractical, especially when only temporary stoppings are needed. They do not lend themselves to use at or near the working faces of mines where heavy blasting is done because of the damage they incur. This paper describes the parachute stopping, quick-fix blowout stopping, and damage-resistant brattice, recently developed by the Bureau of Mines, that are much more suitable for such applications.

OP 43–81. Preparation of Cell Feed Materials for Aluminum and Magnesium Production, by James A. Barclay. Pres. at Workshop on Electrochemistry Applied to Processing of Lunar Materials, Houston, Tex., Sept. 12, 1979; Space Solar Power Review, v. 12, 1981, pp. 259–269. Magnesium chloride for electrolysis to magnesium in a fused-salt bath is made by reacting seawater with milk of lime to precipitate magnesium hydroxide, separating the latter from the barren seawater, dissolving the hydroxide in hydrochloric acid, and crystallizing and drying the compound $MgCl_2 \cdot 1.5H_2O$. Solar evaporation of Great Salt Lake brine, followed by spray drying, also is practiced. Dolomite may be calcined and ground to a fine powder to be mixed with ferrosilicon for reduction to magnesium in vacuum retorts by a nonelectrolytic process. Alumina for smelting to aluminum in Hall-Heroult cells is prepared from bauxite by pressure digestion with strong NaOH solution, thickening, and filtration to separate a waste "red mud," and crystallization of $Al_2O_3 \cdot 3H_2O$ in the presence of seed crystals. The $Al_2O_3 \cdot 3H_2O$ then is calcined to Al_2O_3. The Bureau of Mines and other research on the recovery of alumina from nonbauxitic aluminous materials is discussed, and possible applications of acid leaching, alkaline sinter-caustic leaching, and carbochlorination processes to lunar materials are briefly evaluated.

OP 44–81. Potential "Met" Coke Production Capacity: The Case Is Anything But Closed, by Franklin D. Cooper. 33 Metal Producing, v. 19, No. 9, September 1981, pp. 65–67. A method for determining the annual potential production capacity (ppc) for captive blast furnace coke is described together with examples of relating battery age to productivity, time, and work-hour distributions for coke-oven operations and production costs. Based on a practical best fit combination of known operating variables involving more than 140 captive oven batteries, the study shows that the U.S. steel industry currently has blast furnace coke ppc equivalent to about 62 million to 64 million tons annually of coke-related finished steel shipments.

OP 45–81. The Error in Working-Level Hour. Calculations When the α-Energy From the Radon Daughters Is Not Discriminated, by John Durkin. Health Phys., v. 41, No. 3, September 1981, pp. 477–481. Exact working-level hour cumulative exposure measurements require knowledge of all the potential α energy in 1 liter of air, with this α energy coming from the decay of RaA and RaC' daughters. This can be done by measuring α emission from the daughters with a system that also determines the energy of the α particle, and is, therefore, able to determine which daughter decayed. However, simple counting of total α emission and the assignment of a predetermined energy to the α particle whose value is prescribed from statistical studies of typically found daughter ratios, allow acceptable accuracies in working-level hour measurements.

OP 46–81. Determination of Ground Pressure Existing in a Viscoelastic Rock Mass by Use of Hydraulic Borehole Pressure Cells, by Paul H. Lu. Proc. Internat. Symp. on Weak Rock, Tokyo, Japan, Sept. 21–24, 1981, 7 pp. Accurate magnitude of the biaxial ground pressures existing in a viscoelastic rock mass can be determined by pressure convergence tests with a combination of one cylindrical and two flat hydraulic pressure cells installed in a single hole drilled into that rock mass. Consequently, the triaxial ground pressures can be measured by drilling a pair of orthogonal holes for such instrumentation. Unlike most of the known methods of in situ stress determination that determine the magnitude of the stress indirectly from the elastic stress-strain relation by measuring strain or displacement in place and modulus of deformation in the laboratory, this method directly measures the in situ stress without any knowledge of the value of modulus of deformation. Furthermore, the complete state of stress existing in the viscoelastic rock mass also can be determined by this method if other techniques are supplemented for determining the directions of the principle stresses. In this paper, the theoretical background, measuring equipment, and measurement procedure are discussed. Validity of tions of the principal stresses. In this paper, the are demonstrated by the in situ measurements conducted for a variety of rock types.

OP 47–81. A Comparison of American Safety Performance to Other Countries, by Robert L. Marovelli. Min. Con. J., August 1981, pp. 45–51. Comparisons are made of indicators of safety performance in the United States and primarily the European coal-producing countries of the United Kingdom and the Federal Republic of Germany. Caveats are made that safety performance for U.S. room-and-pillar mining is being compared with European longwall mining and that even a comparison confined to U.S. longwall mining versus European longwall mining would be indirect at best due to important differences in mine development (e.g., U.S. multiple entries versus European single entries) and mining operations.

OP 48–81. Thermodynamic Properties of Aluminum Sulfide (Al_2S_3), by M. J. Ferrante, J. M. Stuve, H. C. Ko, and R. R. Brown. High Temp. Sci., No. 14, 1981, pp. 91–108. Research done at the Bureau of Mines has produced calorimetric data for the low temperature heat capacity from 12 to 312 K and the high temperature relative enthalpy from 400 to 800 K for aluminum sulfide (Al_2S_3). The heat capacity measurements yielded $S°_{298} = 27.927 \pm 0.05$ cal K^{-1} mol^{-1} for the standard entropy at 298.15 K (1 cal = 4.1840 J). The standard enthalpy of formation at 298.15 K, $\Delta Hf°_{298} = 155.6 \pm 0.9$ kcal mol^{-1}, was determined by hydrochloric acid solution calorimetry. The results were combined with the published data for pure aluminum and sulfur to obtain a complete set of thermodynamic data for Al_2S_3 from 0 to 900 K at appropriate temperature intervals.

OP 49–81. Thermodynamic Properties of Cuprous and Cupric Sulfides, by M. J. Ferrante, J. M. Stuve, and L. B. Pankratz. High Temp. Sci., v. 14, 1981, pp. 77–90. Low-temperature heat capacities of Cu_2S(c) and CuS(C) have been measured from

5 to 310 K with an adiabatic calorimeter. The results yielded $S°_{298} = 27.76$ for Cu_2S and $S°_{298} = 16.05$ for CuS, where $S°_{298}$ is the standard entropy at 298.15 K in cal $K^{-1}mol^{-1}$ (1 $cal_{th} = 4.184$ J). High-temperature relative enthalpies have also been measured with a copper-block calorimeter from 298 to 1,600 K for Cu_2S and from 298 to 780 K for CuS. Two solid-solid transitions have been observed for Cu_2S upon heating, the first at 376 K with an isothermal heat absorption of 865 cal mol^{-1}, and the second at 720 K with an isothermal absorption of 280 cal mol^{-1}. The enthalpy of fusion at 1,400 K was 3,070 cal mol^{-1}. No solid-solid phase transitions were observed for CuS from 5 to 780 K. All related thermodynamic properties have been tabulated.

OP 50–81. An Algorithm for Multidimensional Combusting Flow Problems, by Edward J. Kansa. J. Comput. Phys., v. 42, No. 1, July 1981, pp. 152–194. Mathematical effort in combusting fluid flow has been limited due to the numerical difficulties associated with the highly nonlinear processes such as Arrhenius chemical kinetics, radiation, and turbulence superimposed upon fluid flow. Traditional explicit schemes become inefficient in typical combustion problems because the stability requirement is more stringent than the accuracy requirement. The approach taken in this paper is to combine the best features of the block implicit (BI)-ADI partial differential equation (PDE) scheme with the best features of the stiff ordinary differential equation (ODE) schemes and the damped Newton-Raphson and steepest descent nonlinear equation schemes. The resulting algorithm for the highly nonlinear PDE's for combustion problems is very robust and efficient over a wide range of phenomena.

OP 51–81. Selective Extraction of Metals From Pacific Sea Nodules With Dissolved Sulfur Dioxide, by S. E. Khalafalla and J. E. Pahlman. J. Metals, v. 33, No. 8, August 1981, pp. 37–42. A rapid and efficient—almost instantaneous and quantitative—method was devised to differentially leach manganese, nickel, and cobalt to the exclusion of copper and iron from deep sea nodules. In this method, a given weight of raw sea nodules ground to -200 mesh in an aqueous slurry is contacted for 10 min at room temperature with a specified quantity of SO_2. An independent leaching parameter, R, was defined as the ratio of the number of moles of SO_2 in the leaching solution to the weight of sea nodules. Variation of metal extraction with R generates sigmoidal curves characteristic of the metals extracted. A threshold value of R is required to initiate the leaching of a given metal from the mixed oxides. Once the threshold is reached, the metal recovery can rise above 95% in less than 10 min. For increasing value of R the extractability of various metals from Pacific sea nodules by SO_2 follows the order: Mn > Ni > CO >> Fe, AL, Cu. Disparity in the R values permits a variety of selective leaching systems and metal separations simply by changing the quantity of SO_2 in the contact solution.

OP 52–81. The Determination of Chrysotile in Insulation Samples Using Combined TGA–GCA, by John V. Scalera. Proc. North Am. Thermal Analysis Soc. Conf., New Orleans, La., Oct. 19–21, 1981, v. 2, No. 51, pp. 303–309. The identification and quantification of asbestos in insulation materials was investigated by the Bureau of Mines Particulate Mineralogy Unit. One of the objectives is to provide technical assistance on mineral particulate-related problems to other Federal agencies. Quantification of the asbestos content in insulation and construction materials is necessary for the U.S. Environmental Protection Agency to evaluate the potential health risk from exposure to airborne fiber. Gas chromatographic analysis (GCA) of the effluent gases from a thermogravimetric analysis (TGA) balance can provide quantitative data concerning the composition of insulation samples. The GCA peak related to the dehydration of chrysotile occurs within the temperature range of 560° to 660° C. Using chrysotile standards, a linear relationship is obtained relating the summation of the peak heights for water evolved within this 100° C range and the mass of chrysotile present in the sample. The use of a narrow 100° C range to acquire the dehydration data for chrysotile minimizes interferences from hydrates that decompose at lower temperatures and amphiboles that decompose at higher temperatures, for example, gypsum and amosite. GCA data also allow avoiding misinterpreting TGA thermograms for chrysotile when actual $CaCO_3$ decomposition is involved by resolving weight losses in the dehydration range of chrysotile into components of water and CO_2.

OP 53–81. Alumina From Nonbauxitic Resources, by R. C. Kirby and J. A. Barclay Proc. Internat. Committee for the Study of Bauxite, Alumina, and Aluminum, ISCOBA-AIM Conf., Cagliari, Italy, Sept. 26–28, 1979, No. 16, 1981 v. 11, pp. 1–12. Although the United States produces nearly one-third of the world's primary aluminum, it must import more than 90 percent of the bauxite and alumina needed. To test and improve various raw material-process technology alternatives to the Bayer-bauxite process for alumina production, the Bureau of Mines is engaged in an extensive research and development effort. Information thus obtained will be used for decisionmaking on further large-scale testing of the process showing the greatest potential for producing alumina from a domestic nonbauxitic resource. The paper discusses recent research in the Bureau's alumina miniplant project, miniplant support research, and contract studies leading to the preliminary design of a 20-ton-per-day alumina pilot plant.

OP 54–81. Improved Fire Resistance Test Method for Belt Materials, by J. M. Kuchta, M. J. Sapko, F. J. Perzak, and K. E. Mura. Fire Technol., v. 17, No. 2, May 1981, pp. 120–130. A moderately scaled apparatus was developed for determining the fire resistance characteristics of mine conveyor belts and similar type materials. The test method overcomes the limitations of existing laboratory-scale methods and provides a measure of both ignitability and flammability in quantative terms. Data are presented for nine belt materials, and fire resistance ratings are proposed in terms of the flame spread rate, heat release rate, and critical ignitor heat flux.

OP 55–81. Modified-Sulphur Concrete Technology, by William C. McBee, Thomas A. Sullivan, and Bing W. Jong. Proc. Sulphur-81, Internat. Conf. on Sulphur, Calgary, Alberta, Canada, May 25–28, 1981, pp. 367–388. As part of a program to find uses for plentiful resources, the Bureau of Mines has developed a sulfur concrete technology in which chemically modified elemental sulfur is utilized with suitable mineral aggregates to formulate durable, corrosion-resistant materials of construction. This paper describes the chemical, physical, and mechanical characteristics of both sulfur cement and concretes, and the current state-of-the-art for the

manufacture of the materials. Specialized use applications in chemical and metallurgical process environments and current performance data are described.

OP 56–81. Recovery of Zinc From Wastewater Treatment Sludge, by J. B. Stephenson, E. R. Cole, and D. L. Paulson. Res. and Conservation, v. 6, No. 3–4, November 1981, pp. 203–210. Preliminary laboratory work done under a Memorandum of Agreement between the Bureau of Mines Rolla Research Center and the Harrison Radiator Div., General Motors, Corp., has indicated that zinc can be recovered from wastewater treatment sludges generated at the Harrison plant at Lockport, N.Y. The method developed at the Rolla Research Center, Rolla, Mo., for extracting zinc from the sludge involves roasting, leaching-purification, and electrowinning. Roasting to combust the organic fraction and leaching with H_2SO_4 to stabilize the zinc proceeded routinely. Purification and electrowinning followed standard practice for a commercial zinc electrowinning plant, but because of the large amounts of deleterious impurities coextracted with the zinc, as much as 50 times greater than normally encountered in a commercial operation, an extensive modification of the purification procedure was necessary. Zinc was electrowon with good current efficiency and deposit morphology. Residues are being characterized to determine the feasibility of recovering valuable constituents prior to disposal in an environmentally acceptable manner.

OP 57–81. Gasification Pilot Plant Evaluation of CVD Coated Hardware, by J. B. Stephenson and H. O. McDonald. Proc. 8th Internat. Conf. on Chemical Vapor Deposition 1981, Chantilly-Gouvieux, France, Sept. 15–18, 1981, v. 81–7, November 1981, pp. 642–652. The Bureau of Mines, under an interagency agreement with the U.S. Department of Energy (DOE), investigated the feasibility of coating the critical surfaces of valves by chemical vapor deposition (CVD). The purpose of the research was to increase the wear resistance of the valves for use in the abrasive and erosive environment of coal conversion and utilization processes. In-service testing of the CVD-tungsten ball seat was conducted at the DOE Morgantown Energy Technology Center (METC) in Morgantown, W. Va. Tungsten CVD coatings were reproduced on nickel-plated carbon steels and stainless steels by the hydrogen reduction of the tungsten hexafluoride at 325° to 600° C. Tungsten-coated 6-, 10-, and 12-inch (0.15-, 0.25-, and 0.30-meter) ball valve seats were prepared for METC evaluation in their low-Btu coal gasification pilot plant. Use of the CVD-tungsten coated ball valve seat as a seal surface was determined to be satisfactory by METC under their process conditions. Little or no significant wear, other than a lapping effect, was noted on the valve seal surface after 1,230 cycles of operation.

OP 58–81. Recovery of Barite From Tailings Ponds and Bypassed Mining Waste, by G. V. Sullivan and W. E. Lamont. Min. Eng., v. 33, No. 11, November 1981, pp. 1632–1634. As part of its program to conserve domestic mineral resources through advancing mineral resources technology, the U.S. Department of the Interior, Bureau of Mines, conducted investigations to determine the feasibility of recovering high-grade barite concentrates, suitable for use as well-drilling mud, from current and old waste pond materials and materials bypassed in present mining operations. Flotation studies of waste pond samples from Missouri and Nevada yielded barite concentrates containing over 95% $BaSO_4$ with recoveries of 86% and 96%, respectively, of the barite in the flotation feed. Flotation studies of a hard-rock sample from Georgia, currently bypassed in mining, yielded a barite concentrate containing 97% $BaSO_4$ with an attendant recovery of 97% of the barite.

INDEX OF BUREAU OF MINES PUBLICATIONS

ABBREVIATIONS

FBG *	Florida Bureau of Geology
GS *	Geological Survey
HB	Handbook
IC	Information Circular
MI	Mineral Issues
MLA	Mineral Land Assessment
MP	Mineral Perspective
MY †	Minerals Yearbook
OFR	Open File Report
OP	Outside Publication
P	Patent
RI	Report of Investigation
SP	Special Publication
TPR	Technical Progress Report

SUBJECT INDEX

A

* Listed in the "Cooperative Publications" section.

† MY 1980 (v. 1)—Minerals Yearbook, Metals and Minerals, Volume I, 1980; MY 1980 (v. 2)—Minerals Yearbook, Area Reports: Domestic, Volume II, 1980; MY 1980 (v. 3)—Minerals Yearbook, Area Reports: International, Volume III, 1980.

B

C

D

E

F

G

H

I

J

K

N

O

P

Q

R

S

T

U

V

W

Y

Z

AUTHOR INDEX

In the following index, a comma following the name of the first author in an entry indicates that the first author is the senior author; all of the other authors in the entry are junior authors.

A semicolon following the name of the first author in an entry indicates that the first author is a junior author; the name of the senior author immediately follows.

A

B

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D

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E

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