Bureau of Mines
Special Publication

LIST OF BUREAU OF MINES PUBLICATIONS AND ARTICLES

January 1 to December 31, 1980

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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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, 1980. 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]

[1] Single copies available from Section of Publications, Bureau of Mines, U.S. Department of the Interior, 4800 Forbes Avenue, Pittsburgh, Pa. 15213.

[2] See footnote 1.

[3] Available from National Technical Information Service, 5285 Port Royal Road, Springfield, Va. 22161, PB 295 481/AS, paper copy price code A10.

[4] See footnote 1.

[5] See footnote 1.

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

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 symposiums, 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 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.

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, 1980, to December 31, 1980, 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."

BULLETINS

The following publications are sales publications and should be ordered from—

Superintendent of Documents
Government Printing Office
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B 670. Comminution by the Attrition Grinding Process, by Martin H. Stanczyk and I. L. Feld. 1980. 43 pp. 36 figs. As part of its mission to advance minerals technology, the Federal Bureau of Mines has conducted investigations to determine the feasibility of producing subsieve-size material by an attrition grinding method. The Bureau-patented technique involves the intense agitation of a slurry composed of the material to be ground, a granular grinding medium, and a suspending fluid. Investigations were made to determine the efficiency of the method in grinding numerous industrial minerals, metals, and ceramic materials. The research has demonstrated the feasibility of the process for comminuting a variety of materials to extremely fine particle sizes. Transfer of this technology to industry has been achieved, and commercial-scale units currently are being used in the paper-coating clay and titania pigment industries. 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. GPO Stock No. 024-004-02012-1. $2.50.

B 671. Mineral Facts and Problems, 1980 Edition, by Staff, Bureau of Mines. 1981. 1060 pp. This one-volume encyclopedia comprising 80 commodity chapters and an explanatory introduction contains comprehensive information on metals, nonmetals, and industrial gases. Commodity chapters cover such topics as industry structure, reserves and resources, uses, technology, supply-demand relationships, by-products and coproducts, strategic considerations, economic factors and problems, operating factors and problems, and outlook and forecasts to 2000. GPO Stock No. 024-004-02072-5. $23.

Copies of chapters are also available from the Superintendent of Documents.

Aluminum, by Horace F. Kurtz and Luke H. Baumgardner. 26 pp. 13 figs. GPO Stock No. 024-004-02058-0. $2.25.

Antimony, by John A. Rathjen. 12 pp. 2 figs. GPO Stock No. 024-004-01983-2. $1.50.

Arsenic, by J. Roger Loebenstein. 8 pp. 1 fig. GPO Stock No. 024-004-02035-1. $1.50.

Asbestos, by Robert A. Clifton. 17 pp. 7 figs. GPO Stock No. 024-004-02040-7. $1.50.

Barite, by David E. Morse. 12 pp. 1 fig. GPO Stock No. 024-004-02041-5. $1.50.

Beryllium, by Benjamin Petkof. 10 pp. 1 fig. GPO Stock No. 024-004-01998-1. $1.50.

Bismuth, by Robert J. Bascle and James F. Carlin, Jr. 9 pp. 2 figs. GPO Stock No. 024-004-01980-8. $1.50.

Boron, by Sandra T. Absalom. 15 pp. 3 figs. GPO Stock No. 024-004-01981-6. $1.50.

Bromine, by Phyllis A. Lyday. 9 pp. 1 fig. GPO Stock No. 024-004-02062-8. $1.75.

Cadmium, by John M. Lucas. 12 pp. 1 fig. GPO Stock No. 024-004-02000-8. $1.50.

Cement, by James T. Dikeou. 16 pp. 2 figs. GPO Stock No. 024-004-02036-9. $2.00.

Cesium, by Robert J. Bascle. 8 pp. 1 fig. GPO Stock No. 024-004-01972-7. $1.50.

Chromium, by John L. Morning, Norman A. Matthews, and E. C. Peterson. 16 pp. 2 figs. GPO Stock No. 024-004-02019-9. $1.50.

Clays, by Sarkis G. Ampian. 15 pp. 1 fig. GPO Stock No. 024-004-02045-8. $2.00.

Cobalt, by Scott F. Sibley. 16 pp. 2 figs. GPO Stock No. 024-004-01999-9. $1.50.

Columbium, by Thomas S. Jones. 12 pp. 1 fig. GPO Stock No. 024-004-02006-7. $1.50.

Copper, by H. J. Schroeder and James H. Jolly. 18 pp. 3 figs. GPO Stock No. 024-004-01977-8. $1.50.

Corundum and Emery, by Harold A. Taylor, Jr. 11 pp. 2 figs. GPO Stock No. 024-004-02060-1. $1.75.

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Diatomite, by Arthur C. Meisinger. 7 pp. 1 fig. GPO Stock No. 024-004-02020-2. $1.50.

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Fluorine, by David E. Morse. 19 pp. 1 fig. GPO Stock No. 024-004-02031-8. $1.50.

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Gem Stones, by G. David Baskin. 12 pp. 3 figs. GPO Stock No. 024-004-02033-4. $1.75.

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Iron Ore, by E. C. Peterson. 21 pp. 5 figs. GPO Stock No. 024-004-01996-4. $1.50.

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Manganese, by Gilbert L. DeHuff and Thomas S. Jones. 14 pp. 1 fig. GPO Stock No. 024–004–02009–1. $1.50.

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Quartz Crystal, by Alvin B. Zlobik. 8 pp. 3 figs. GPO Stock No. 024–004–02046–6. $1.75.

Rare-Earth Elements and Yttrium, by Christine M. Moore. 16 pp. 1 fig. GPO Stock No. 024–004–01989–1. $1.50.

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Tin, by James F. Carlin, Jr. 13 pp. 2 figs. GPO Stock No. 024–004–02049–1. $1.75.

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Tungsten, by Philip T. Stafford. 18 pp. 4 figs. GPO Stock No. 024–004–02008–3. $1.50.

Uranium (Depleted), by William S. Kirk. 7 pp. 1 fig. GPO Stock No. 024–004–02063–6. $1.75.

Vanadium, by George A. Morgan. 10 pp. 1 fig. GPO Stock No. 024–004–01994–8. $1.50.

Vermiculite, by Arthur C. Meisinger. 9 pp. 1 fig. GPO Stock No. 024–004–02011–3. $1.50.

Zinc, by V. Anthony Cammarota, Jr. 19 pp. 3 figs. GPO Stock No. 024–004–02038–5. $1.50.

Zirconium and Hafnium, by Langtry E. Lynd. 16 pp. 2 figs. GPO Stock No. 024–004–02059–8. $2.00.

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 1980 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.
Gold and Silver.
Magnesium and Magnesium Compounds.
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.
Copper Industry.
Diatomite.
Feldspar and Related Minerals.
Ferroalloys.
Fluorspar.
Gallium.
Gem Stones.
Gold and Silver.
Graphite, Natural.
Gypsum.
Gypsum Mines in the United States.
Industrial Explosives.
Iodine.
Iron and Steel.
Iron and Steel Scrap.
Iron Ore.
Iron Oxide Pigments.
Kyanite and Related Minerals.
Lead Industry.
Lime.
Lime Plants in the United States.
Lithium.
Magnesium and Magnesium Compounds.
Manganese.
Mercury.
Mica.
Mica, Block and Film.
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.
World Mineral Production.
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.

MINERALS YEARBOOK

The 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 of the Minerals Yearbook contains chapters on metal and nonmetal commodities. Volume I contains a general review chapter on the mineral industries, a statistical summary, and a chapter on mining and quarrying trends.

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 identical to that in Volume I.

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 minerals in general and their relation to the world economy.

1977 MINERALS YEARBOOK

Volume I, Metals and Minerals, prepared by the staff of the Bureau of Mines. 1980. 75 ch. 1066 pp. GPO Stock No. 024-004-01965-4. $17.

Volume II, Area Reports: Domestic, prepared by the staff of the Bureau of Mines. 1981. 52 ch. 665 pp. GPO Stock No. 024-004-02067-9. $13.

Volume III, Area Reports: International, prepared by the staff of the Bureau of Mines. 1981. 93 ch. 1243 pp. GPO Stock No. 024-004-02073-3. $17.

1978-79 MINERALS YEARBOOK

Volume I, Metals and Minerals, prepared by the staff of the Bureau of Mines. 1980. 73 ch. 1063 pp. GPO Stock No. 024-004-02021-1. $15.

Volume II, Area Reports: Domestic, prepared by the staff of the Bureau of Mines. 1981. 53 ch. 596 pp. GPO Stock No. 024-004-02064-4. $12.

Volume III, Area Reports: International, prepared by the staff of the Bureau of Mines. 83 ch. 1250 pp. GPO Stock No. 024-004-02066-1. $17.

REPORTS OF INVESTIGATIONS

RI 8405. Electrochemical Determination of Gibbs Energies of Formation of MoS_2 and WS_2, by Seth C. Schaefer. 1980. 17 pp. 4 figs. As part of the Bureau of Mines effort to provide thermodynamic data for the advancement of mineral technology, the Gibbs energies of formation of MoS_2 (molybdenite) and WS_2 (tungsten disulfide) were determined with high-temperature galvanic cells employing stabilized ZrO_2 (zirconia) as the electrolyte. A third-law analysis of the present data yielded a standard enthalpy of formation $\Delta H°_{298}f$ of -67.36 ± 0.60 kcal/mole of MoS_2. Experimental entropy and enthalpy data are needed to extend the present Gibbs energy of formation data to wider temperature ranges and derive a standard enthalpy of formation of WS_2

RI 8409. Enthalpies of Formation α- and β-Magnesium Sulfate and Magnesium Sulfate Monohydrate, by H. C. Ko and G. E. Daut. 1980. 8 pp. As part of the Federal Bureau of Mines effort to provide thermodynamic data for the advancement of minerals technology, energy conservation, and environmental preservation, the standard enthalpies of formation of α-magnesium sulfate, β-magnesium sulfate, and magnesium sulfate monohydrate were determined by hydrochloric acid solution calorimetry. The values of the standard enthalpies of formation in kcal per mole at 298.15 K are -307.95 ± 0.14 for α-$MgSO_4$, -307.03 ± 0.13 for β-$MgSO_4$, and 384.72 ± 0.13 for $MgSO_4 \cdot H_2O$.

RI 8410. Thermodynamic Properties of Potassium Metasilicate and Disilicate by R. P. Beyer, M. J. Ferrante, R. R. Brown, and G. E. Daut. 1980. 21 pp. 2 figs. The Bureau of Mines has measured the low-temperature heat capacities and high-temperature enthalpies of crystalline $K_2Si_2O_5$ as part of a program for advancing mineral resources technology with energy economy. High-temperature enthalpies of glassy and liquid $K_2Si_2O_5$ and crystalline K_2SiO_3 were also measured. An adiabatic calorimeter operation over the range 5 to 308 K was used for the heat capacity measurements for $K_2Si_2O_5$ from which the standard entropy at 298.15 K, $S°_{298} = 45.55 \pm 0.05$ cal/deg-mole, was calculated. Tabulated values of $C°_p$, $S°$, $-(G°-H°_0)/T$, and $H°-H°_0$ from 5 to 300 K are given for $K_2Si_2O_5$. A copper-block drop calorimeter was used in the enthalpy measurements, operating from 298.15 to 1,198 K for K_2SiO_3 and from 298.15 to 1,453.8 K for $K_2Si_2O_5$. No transitions were found for K_2SiO_3. The $K_2Si_2O_5$ showed two reversible first-order transitions, one at 510 K with a heat of transition of 0.29 kcal/mole and one at 867 K with a heat of transition of 0.38 kcal/mole. The heat of fusion for $K_2Si_2O_5$ was calculated to be 8.42 kcal/mole. Relative enthalpies are given in equation form, and high-temperature values are tabulated for $C°_p$, $S°$, $-(G°-H°_{298})/T$, and $H°-H°_{298}$. Also tabulated are $\Delta H°$, $\Delta G°$, and log K for formation of K_2SiO_3 and $K_2Si_2O_5$ from both the elements and the oxides.

RI 8411. Iron-Based Alloys Strengthened by Ternary Laves Phases, by J. S. Dunning. 1980. 13 pp. 9 figs. A primary goal of the Federal Bureau of Mines is to minimize the requirements for scarce mineral commodities through conservation and substitution of more abundant elements, such as iron and molybdenum. One example of this is the research effort to devise substitute materials for specialty alloys, thereby conserving nickel and chromium in high-volume stainless steels. As a possible substitute for the solid solution strengthening of chromium and nickel, the precipitation hardening characteristics of a number of binary iron-based systems in which Laves phase precipitates, such as Fe_2Mo, are formed were investigated. Several hardening responses were observed, but none were ideal. The Fe-Ta binary system had the highest magnitude of hardening, even with low alloy additions, and the Fe-Mo system had unique stability at temperature. Accordingly, the Fe-Mo-Ta system was selected for study to determine if a ternary Laves phase could combine hardening with long-term stability at elevated temperature. Hardening and stability were reflected in excellent elevated temperature, tensile, and stress rupture strengths. Future research will study ternary systems based on more abundant resource materials, such as the Fe-Mo-Ti system, together with additions, such as aluminum and minimal chromium, to provide oxidation resistance.

RI 8412. Development Testing and Analysis of Steel-Fiber-Reinforced Concrete Mine Support Members. Support System Design and Results of Laboratory Investigation and Full-Scale Testing, by G. L. Anderson and T. W. Smelser. 1980. 38 pp. 13 figs. This Federal Bureau of Mines report presents the design analysis, laboratory testing, full-scale crib testing, and analysis of results of steel-fiber-reinforced concrete mine support members developed at the Spokane (Wash.) Research Center. The objective of the work was to design and laboratory-test fiber-reinforced concrete mine support members for best configuration, fiber material, fabrication method, handling, strength, stiffness, and cost. The results indicate the steel-fiber-reinforced concrete (SFC) support members that were developed offer significant improvements in stiffness and strength in compression compared with wood supports, yet they avoid the brittle or catastrophic compressive failure mode of plain concrete. The results also indicate SFC support members may offer significant cost savings compared with wood supports.

RI 8413. Development of a Method To Detect Geologic Faults and Other Linear Features From LANDSAT Images, by Richard D. Burdick and Robert A Speirer. 1980. 74 pp. 16 figs. Methods of detecting geologic faults and other linear features by means of processed LANDSAT satellite images have gained prominence during the past several years. There have been numerous programs written to pick these "lineaments," but they have been almost universally tailored to large computers. This Bureau of Mines report describes a detection method developed for use with a minicomputer. The method comprises a suite of programs that scans an image for all "potential" lineaments. From this partially analyzed data, the final lineaments are picked by another routine. The method was field tested in an area of

south-central Wyoming, and results indicated good agreement between computer-picked lineaments and ground features. Most of the known geologic faults in the area were picked by the method. Such features as roads and trails were also picked but were easily distinguished from faults during field inspection. The method is relatively new but promises to be a viable reconnaissance technique for the mining industry in geologic structure analysis.

RI 8414. Least Squares Calculation of Horizontal Stresses From More Than Three Diametral Deformations in Vertical Boreholes, by Wilbur I. Duvall and James R. Aggson. 1980. 12 pp. The borehole deformation gage and overcoring techniques developed by the Bureau of Mines form one of the primary methods of determining in situ rock stress. This report describes a least squares method of calculating the average rock stress components in the horizontal plane from more than three diametral deformation measurements in a vertical borehole. This least squares analysis provides a means of determining the multiple correlation coefficient, the variance, and the scatter for a set of deformation measurements. From this information, confidence limits can be calculated for the secondary horizontal principal stresses and their directions. The material presented in this report can be used as a guide to the development of least squares solutions for stress measurement techniques other than the borehole deformation method. Since the statistical information that results from the least squares method is extremely useful in the interpretation of results, it is recommended that a least squares analysis be used on stress measurement data whenever possible.

RI 8415. Laboratory Corrosion Studies in Low- and High-Salinity Geobrines of the Imperial Valley, Calif., by S. D. Cramer and J. P. Carter. 1980. 30 pp. 12 figs. 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, the corrosion resistance of 31 iron-, nickel-, aluminum-, copper-, titanium-, and molybdenum-base alloys was characterized and evaluated in laboratory corrosion studies in low- and high-salinity geobrines representative of those found in the Imperial Valley, Calif. General, crevice, pitting, weld, and stress corrosion were measured at 105° and 232° C in deaerated brines and brines containing dissolved O_2, CO_2, and CH_4. General corrosion rates in deaerated brines at 105° and 232° C were usually below 5 mpy for the alloys tested except carbon steel, the low-alloy steels, Monel 400, 70–30 cupronickel, and the aluminum-base alloys. Dissolving carbon dioxide and methane in the brines at 232° C did not markedly alter these results. However, the introduction of oxygen, which can enter the brine during process operations, seriously degraded the corrosion resistance of many alloys by increasing the incidence of stress corrosion cracking, crevice corrosion and, except for the titanium-base alloys, pitting. In deaerated brine at 232° C, the general corrosion rates for carbon steel and the low-alloy steels were relatively unaffected by pH in the range of 6.1 to 3.0. However, general corrosion rates increased sharply below pH 3.0. In deaerated brine at 232° C, welds in several iron-, nickel-, and titanium-base alloys corroded at rates comparable to the general corrosion rates of the alloys, but the addition of oxygen to the brine increased corrosion rates for welds in Inconel 625 and E-Brite 26–1. Alloys exhibiting good corrosion resistance in the deaerated Salton Sea KGRA-type brine at 232° C were E-Brite 26–1, Inconel 625, Hastelloy S, Hastelloy G, Hastelloy C-276, TiCode-12, Ti-0.2Pd, Ti-2Ni, Ti-1.7W, and TZM. The alloys most resistant to corrosion in oxygenated Salton Sea KGRA-type brine at 232° C were the titanium-base alloys. These alloys appear the most suitable for use in the construction of geothermal resource recovery plants. Carbon steel and the low-alloy steels are unsatisfactory for high-temperature, high-salinity brines and alternative low-cost materials with improved corrosion resistance should be sought.

RI 8416. Development of a Mechanical Roof Breaker for Ground Control in Longwall Operations Under Massive Roof, by Sathit Tandanand. 1980. 20 pp. 9 figs. Massive roof overlying the working seam in longwall operations can cause hazards if it does not cave readily behind the face supports. The overhang thus formed can overload the supports and endanger personnel when it collapses suddenly as a large rock mass. This Bureau of Mines report proposes the use of a concentrated load, either strip or point loading, applied onto the roof with the help of the upward thrust of the face supports. An experiment was conducted in the laboratory to obtain information about break characteristics and the values of significant parameters of three sedimentary rocks. The results were used to determine the breaking load requirements for a strong roof possibly encountered in typical longwall operations. The results show that the roof slab of moderate thickness can be fractured within the load capacity of off-the-shelf powered supports.

RI 8417. A Rapid-Set Cement Suitable as a Molding Sand Binder for Small Ferrous Castings, by S. D. Sanders, E. D. Scott, and G. V. Sullivan. 1980. 16 pp. 11 figs. Goals of the Bureau of Mines include utilizing readily available minerals as substitutes for scarce mineral commodities and minimizing occupational hazards associated with mineral processing occupations. Therefore, the Tuscaloosa Research Center investigated using rapid-set cement as a suitable molding sand binder for small ferrous castings; currently petroleum-based binders are used. Substitution of a rapid-set cement would eliminate organic vapors associated with the petroleum-based binders; these vapors constitute occupational hazards and environmental pollutants. A binder containing 60 percent white portland cement (WPC) and 40 percent calcium aluminate (CA) would be an acceptable and economic substitute for petroleum-based binders where the foundry requirements are compatible with its limitations. It produced a set time and a pattern strip time of less than 1 hour. Cement, sand, and water mixtures developed compressive strengths from about 40 to 75 psi after 2 hours and from 120 to 130 psi after 24 hours. Tensile strengths of 18 to 22 psi were obtained after 2 hours, increasing to 30 to 35 psi after 24 hours. The addition of about 1 percent polyphosphate to the sand-cement-water mixture doubled the compressive strength and increased the tensile strength about 50 percent after 4 hours, but also increased the set time from 30 minutes to 1 to 1–½ hours. Polyvinylacetate (PVA) resin latex additions resulted in rapid strength development. When castings were poured into the cement-bonded molds, the surface finish was fair to good on gray iron castings, but some areas of burn-on were present on steel castings. Using a graphite wash on the cement-

bonded molds produced good surfaces on gray iron castings. 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 8418. High-Temperature Enthalpy and X-Ray Powder Diffraction Data for ZrI_4, by M. J. Ferrante and R. A. McCune. 1980. 8 pp. 1 fig. New data on zirconium tetraiodide (ZrI_4) have resulted from high-temperature enthalpy and X-ray powder diffraction studies conducted by the Bureau of Mines. These studies were undertaken as part of the Bureau's efforts to provide important thermodynamic data essential to the advancement of mineral resources technologies that can be employed with minimal energy requirements and minimal environmental degradation. Enthalpies were measured with a copper-block drop calorimeter. No transitions or other anomalies were found. Tabulated values are given from 298.15 to 772 K for relative enthalpy, heat capacity, entropy, and Gibbs energy function. Enthalpies are expressed in equation form and combined with data from the literature to calculate values of the standard enthalpy of formation and the Gibbs energy of formation. X-ray powder diffraction data indicate that ZrI_4 is primitive cubic with a lattice parameter of 11.79 A and is isostructural with stannic iodide (SnI_4).

RI 8419. Solvent Extraction of Cobalt From Laterite-Ammoniacal Leach Liquors, by D. N. Nilsen, R. E. Siemens, and S. C. Rhoads. 1980. 23 pp. 13 figs. The Bureau of Mines is developing a method to recover Ni, Co, and Cu from laterites containing less than 1.2 pct Ni and 0.25 pct Co. The method consists of the following basic unit operations: (1) reduction roasting, (2) leaching, (3) solvent extraction, and (4) electrowinning. The method reflects three Bureau of Mines objectives: (1) recovery of critical minerals that are domestically in short supply from low-grade domestic laterites, (2) lower processing energy requirements, and (3) solution recycling. This report deals with the extraction of cobalt and the preparation of a suitable cobalt electrolyte by solvent extraction from liquor produced by this method. Nickel and copper are coextracted with LIX64N from an ammoniacal ammonium sulfate leach liquor containing about 1.00 g/l Ni, 0.30 g/l Co, 0.03 g/l Cu, and 0.02 g/l Zn. Cobalt (III) in the nickel-copper barren raffinate is reduced to cobalt (II) with cobalt metal. Reduction of cobalt (III) to cobalt (II) greatly aids subsequent extraction. Commercially available XI-51 extracts about 94 pct of the cobalt from the treated raffinate in one stage in a laboratory mixer-settler continuous circuit. Ammonia loaded on the solvent is removed in two washing steps. About 94 pct of the cobalt then is stripped from the XI-51 in one stage with spent cobalt electrolyte containing about 77 g/l Co and 18 g/l sulfuric acid (H_2SO_4). Electrolytes containing less H_2SO_4 also may be used. Preliminary data indicate that coextracted zinc may be removed from pregnant cobalt electrolyte containing 3 g/l or less H_2SO_4 with di-(2-ethylhexyl) phosphoric acid (D2EHPA).

RI 8420. Thermodynamic Properties of Ferric Oxychloride and Low-Temperature Heat Capacity of Ferric Trichloride, by J. M. Stuve, M. J. Ferrante, D. W. Richardson, and R. R. Brown. 1980. 14 pp. 3 figs. This Bureau of Mines investigation measured the low-temperature heat capacities of FeOCl(c) and $FeCl_3$(c) in the temperature ranges of 6 to 305 K and 4.6 to 300 K, respectively. The standard entropies (S°, 298.15 K) of FeOCl(c) and $FeCl_3$(c) were derived as 19.73±0.03 cal/deg-mole and 35.33 ±0.07 cal/deg-mole. A large lambda transition was observed in the heat capacity of $FeCl_3$(c) at 8.4 K The standard enthalpy of formation ($\Delta H°f$, 298.15 K) of FeOCl(c) was determined to be -98.23±0.22 kcal/mole by HCl solution calorimetry. High-temperature enthalpy measurements ($H - H_{298.15}$) of FeOCl(c) were determined to 700 K by precision drop calorimetry. Standard thermodynamic formation data and related functions were tabulated at various temperatures for FeOCl(c) and $FeCl_3$(c).

RI 8421. Evaluating Clay Resources From Clay County, Ga., for Structural Clay Products, by K. J. Liles and H. Heystek. 1980. 28 pp. 23 figs. To encourage the development and conservation of the Nation's ceramic raw materials, the Bureau of Mines, U.S. Department of the Interior, under an agreement with the Georgia Department of Natural Resources, evaluated samples from a clay resource located in Clay County, Ga., for use as a raw material for lightweight aggregate. The physical properties of clay samples, taken from 5-foot increments of drill cores from 11 holes, were determined. Raw materials were plasticized and extruded to produce ½-inch by 1-inch pieces and fired in a rotary kiln to produce lightweight aggregate samples. The resulting expanded material had excellent loose pour weights ranging from 30 to 37 lb/cu ft. The expanded test materials were crushed, sized, and used as aggregate to form concrete cylinders. The unit weight and compressive strength of the cylinders averaged 106 lb/cu ft and 3,350 lb/sq in, respectively; these values meet American Society for Testing and Materials specifications for structural concrete. The clay from the drill cores was also used to make test bars that were evaluated for building brick. 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 8422. Two-Measurement Methods for Working-Level Determinations of Radon Daughters, A Theoretical Study, by Robert F. Holub. 1980. 47 pp. 42 figs. The Bureau of Mines has evaluated four working-level radiation-measurement methods and optimized them from the inherent and statistical error standpoint. Optimization with respect to various sampling and measurement times yielded no marked improvement over the existing methods. However when appropriate approximations are made and evaluated, these two-measurement methods can be reduced to simple formulas, eliminating a need to use nomograms. These modified methods also have improved inherent error characteristics. A new method—a combination of two existing methods—with improved inherent and statistical errors has been suggested. All the pertinent equations are given, together with the computer program, so that any two-measurement method can be readily evaluated.

RI 8423. A Proportional Temperature Controller With Automatic Shutoff, by George M. Lucich and Philip W. Holland. 1980. 8 pp. 4 figs. This report describes a sensitive, proportional temperature controller developed by the Bureau of Mines that is useful in the temperature range from 40° to 400° C with an accuracy of ±0.1° C. A temperature controller of this kind is potentially useful for regulat-

ing temperatures in air chambers, liquid baths, furnaces, and reaction vessels, and for other applications. This instrument was developed to control the duration and temperature of the heating cycle of a charcoal-filled adsorber that is part of a special helium analyzer used by the Bureau. The controller was made from commercially available parts, and can be easily modified to provide continuous temperature control. The circuit is solid-state and employs no electromechanical devices. Over a 2-year period of use as a component of the special helium analyzer, this temperature controller performed successfully and required no maintenance.

RI 8424. A Fail-Safe Control System for a Mine Methane Pipeline, by M. C. Irani, F. F. Kapsch, P. W. Jeran, and S. J. Pepperney. 1980. 11 pp. 7 figs. The Bureau of Mines has designed and put into operation a fail-safe control system for use in underground coal mines equipped with methane drainage pipelines. This control system can detect certain unsafe conditions and respond by automatically shutting off the flow of methane from the degasification borehole to the drainage pipeline. Methane flow is shut off when the methane content in the return airways reaches a predetermined level (typically 1.5 pct), when the methane drainage pipeline is ruptured by roof fall, or when there is an electric power failure. The fail-safe control system was designed using commercially available components and a methane analyzer system previously developed by the Bureau. The fail-safe system consists of a unit that combines a shutoff valve and pneumatic valve actuator, and electronic and mechanical equipment designed to detect hazards and effect shutdown. The fail-safe control system was designed to meet regulatory requirements issued by the Mine Safety and Health Administration (MSHA), U.S. Department of Labor, and State regulatory bodies for the same operation of underground methane pipelines used for mine degasification. MSHA has inspected and tested this system and permitted its use in two mines. The Bureau installed the fail-safe system in two working coal mines, where successful performance has been demonstrated.

RI 8425. Electrochemical Corrosion of Iron-Chromium Alloys Under Ultra-High-Purity Conditions, by Murray Rosen. 1980. 66 pp. 30 figs. This Bureau of Mines study used rigorously maintained, ultra-high-purity electrochemical systems for in situ characterization of Fe-18Cr surfaces for corrosion studies in well-defined aqueous environments that heretofore were unavailable by normal or conventional laboratory techniques. Contrary to data in the literature, Fe-18Cr does *not* spontaneously corrode in 1*N* H_2SO_4 solutions of ultra-high-purity; instead, it forms a state that is dependent on the deaerating gas. In He-saturated solution the behavior is one of long-term inactivity at potentials that are usually associated with passivity. In H_2-saturated solution a steady-state, open-circuit potential is spontaneously formed that is within -1 mv of the reversible hydrogen electrode potential for that solution. This noncorroding state in H_2-saturated solution is termed "stability" because even though corrosion is thermodynamically possible at -1 mv, the electrode is kinetically stable and exhibits, over a narrow potential range, equilibrium behavior that is associated with the H^+/H_2 exchange reaction. In situ electrochemical measurements of the Fe-18Cr solution interface indicated that stability was dependent not on the presence of surface metal-oxygen species, but on the absence of corrosion-inducing species. Without altering the ultra-high purity of an H_2-saturated solution, it was determined that corrosion could be induced and stability restored by in situ electrochemical control of the surface concentration of hydrogen atoms. A mechanism has been proposed to account for the hydrogen atom dependency. The spontaneous behavior of Fe-18Cr in these ultra-high-purity solutions in combination with the electrochemical techniques makes it possible to specifically measure the synergistic effects of individual components of a metallurgical environment. By first establishing this stable state, and then making controlled additions of selected chemical species, one can obtain a fundamental understanding of corrosion-inducing species.

RI 8426. Development of Analytical Reference Materials for Refuse-Derived Fuels, by Stephen L. Law, Benjamin W. Haynes, and William J. Campbell. 1980. 11 pp. Municipal solid waste (MSW), presently a major disposal problem, represents a significant source of metals and glass together with a combustible fraction that could be used to supplement coal and oil and in generating heat and electricity. This combustible fraction represents ~70 weight-percent MSW; therefore, effective utility of this fraction is an essential part of the Bureau of Mines program to conserve and increase the Nation's mineral and fuel supply through recycling of urban waste. Because of the increasing national interest in this important fuel supplement, the U.S. Department of the Interior, Bureau of Mines prepared a refuse-derived fuel material as a proposed reference material for use by other laboratories to evaluate their analytical procedures. This reference material was prepared by combining MSW light combustibles from Tampa, Fla., Montgomery County, Md., and Tulsa, Okla., then shredding, milling, and blending the composite material. Homogeneity of the refuse-derived fuel reference material (RDFRM) appears to be acceptable based on analytical values for replicate analyses. Concentration data for major, minor, and trace elements together with proximate analyses are provided in this report. Aliquots of the RDFRM are available to interested laboratories upon request.

RI 8427. Adsorption of Heavy Metal Ions by Xanthated Sawdust, by C. M. Flynn, Jr., T. G. Carnahan, and R. E. Lindstrom. 1980. 12 pp. 3 figs. The Bureau of Mines prepared and investigated xanthated sawdust adsorbents to determine their effectiveness in removing heavy metal ions from dilute aqueous solutions, mine-drainage waters, and brines. Stripping of the metal values from the metal-laden adsorbent was also investigated. The treated sawdusts had an adsorption capacity of 0.3 to 0.4 meq/g dry adsorbent for Mn, Co, Ni, Cu, Ag, Zn, Cd, Hg, or Pb from feed solutions with pH 5 to 6. The feed solutions tested included mine-drainage waters and geothermal brine. Effluent metal concentrations as low as 0.05 to 0.1 mg/l were obtained at effluent pH values of 6 to 9. The order of affinity of metals for the sawdust adsorbent is $Na << Ca \sim Mg \sim Mn < Zn < Ni < Cd < Pb \sim Cu$. The presence of Ca, Mg, or Na in concentrations as high as 2 g/l does not seriously impair the heavy-metal adsorption. Metals were desorbed from the metal-laden adsorbent by elution with dilute mineral acids, sodium cyanide, or salts of ethylenediaminetetraacetic acid.

RI 8428. Recovery of Silver From Chloride Leach Solutions by Iodide Precipitation, by T. G. Carnahan, C. M. Flynn, Jr., and R. F. Lindstrom. 1980. 9 pp. 3 figs. The Federal Bureau of Mines investigated, on a laboratory scale, a technique for recovery of silver from pregnant solutions generated in the hydrometallurgical treatment of complex base-metal sulfide concentrates with oxidizing chloride media. This technique provides a means for recovery and simplified reduction of accessory silver to metal from chloride solutions. The method consists of adding NaI or KI to the solution to precipitate AgI, which is then contacted with Na_2S to produce Ag_2S and to regenerate the iodide salt solution. Silver recoveries range from 99 pct with 20 pct excess iodide precipitant, to 92 pct when the theoretical stoichiometric amount of precipitant is employed The Ag_2S product can be reduced to silver metal by contact with aluminum chips in NaOH solution followed by purification with conventional fire refining techniques.

RI 8429. Pilot-Scale Studies on the Composition and Characteristcs of Urban Refuse, by R. S. DeCesare, F. J. Palumbo, and P. M. Sullivan. 1980. 32 pp. 9 figs. Operation of the Bureau of Mines raw refuse continuous separation pilot plant is described, including modifications made to plant equipment for improved performance. Products recovered from refuse, many of which have been evaluated by other laboratories and private firms are discussed. Sampling procedures used in the pilot plant and detailed data obtained from processing refuse from 13 municipalities are presented in appendixes. Fuel evaluations made on combustible fractions of refuse from the various municipalities are also presented. Information and data obtained at the pilot plant have been used to assist many municipalities in solving their urban refuse problems.

RI 8430. High-Temperature Corrosion Resistance of Alumina Refractories to Lignite Ash Slags, by J. E. Pahlman, C. F. Anderson, and S. E. Khalafalla. 1980. 20 pp. 11 figs. As part of its goal to minimize the requirements for mineral commodities through conservation and substitution, the Bureau of Mines is conducting research to determine the resistance of alumina refractories to corrosion by alkali-containing slags that could result from burning of the abundant Western lignites in metallurgical operations. Static corrosion tests were performed at 1,000° to 1,350° C and dynamic tests were performed at 1,400° to 1,600° C to investigate the stability of refractory specimens in slag environments. In general, the degree of refractory attack increased with decreasing alumina content in the refractory and with increasing alkali content of the lignite ash. The parabolic kinetics observed in static tests suggested that a reaction product layer is formed through which ionic diffusion must occur to sustain the reaction with the refractory material. The linear kinetics observed in dynamic tests in high-viscosity slags indicated a shearing of the reaction product layer by viscous slags. The observed lesser attack of refractories by low-viscosity slags can be explained on this basis. Two 99-percent-alumina refractories and two 90-percent alumina refractories formed an expanded protective layer with the more viscous slags but not with the less viscous slags. Corrosion of 90-percent-alumina refractories increased exponentially with temperature. In refractories with the same nominal alumina content, those that contain a combination of α-Al_2O_3 and mullite ($3Al_2O_3 \cdot 2SiO_2$) have better corrosion resistance than those containing a combination of α-Al_2O_3, cristobalite (SiO_2 mineral), and mullite. In alkali environments (1,300° to 1,400° C), 90- to 99-percent-alumina refractories are recommended for use as furnace linings.

RI 8431. Electrochemical Corrosion Behavior of Alloys Formed by Ion Implantation, by B. S. Covino, Jr., B. D. Sartwell, G. R. Conner, and P. B. Needham, Jr. 1980. 20 pp. 8 figs. The Bureau of Mines, U.S. Department of the Interior, is conducting research to devise substitute corrosion-resistant materials by using ion implantation to form alloyed regions near the surfaces of metals. These alloys were prepared by implanting 25-kev Cr^+ and/or Ni^+ ions into iron. Their resistance to corrosive attack was evaluated by determining their anodic polarization behavior under potentiodynamic conditions in a solution containing sodium chloride, boric acid, and sodium borate. These electrochemical studies have shown that the general corrosion resistance of ion-implanted alloys was comparable to nominally equivalent bulk alloys. The pitting-corrosion resistance of the ion-implanted alloys was superior to that of iron, although not as good as that of most of the bulk alloys tested.

RI 8432. Extracting Lithium From Clays by Roast-Leach Treatment , by J. T. May, D. S. Witkowsky, and D. C. Seidel. 1980. 16 pp. 3 figs. The Federal Bureau of Mines investigated the extraction of lithium from hectorite-type clay deposits found on the Nevada-Oregon border. Two clay samples were used in the investigation; one contained 0.36 pct Li and the second contained 0.64 pct Li. The purpose of this laboratory-scale research was to determine how these clays responded to different extraction techniques. Extraction techniques investigated were sulfuric acid leach, sulfuric acid bake-water leach, and roast-water leach procedures with cholorides, sulfates, carbonates, and combinations of these reagents. The processing characteristics of the clay samples showed significant variations, and no one technique was effective for both materials. Lithium extractions near 90 pct were achieved during these exploratory studies.

RI 8433. Spectrophotometric Determination of Uranium Using Dibenzoylmethane, by M. M. Jones, J. S. Macduff, and A. B. Whitehead. 1980. 12 pp. 2 figs. A procedure for the spectrophotometric determination of uranium has been developed in support of minerals research being conducted by the Bureau of Mines. Uranium is separated from the sample by tributylphosphate extraction from acid solution containing added aluminum nitrate and (ethylene dinitrilo)-tetraacetic acid solutions. The colored uranium-dibenzoylmethane complex is developed in the organic phase by adding an ethanol solution of dibenzoylmethane buffered with triethanolamine. Absorbance is measured at 410 nanometers, and the response is linear up to at least 100 micrograms U_3O_8 in the aqueous aliquot taken for analysis. Aliquots containing as little as 8 micrograms U_3O_8 may be analyzed with relative errors no greater than ± 5 percent. For aliquots containing at least 35 micrograms U_3O_8, relative standard deviation at the 95-percent confidence level is about ± 2.2 percent. Appropriate procedures are given for analyzing a wide variety of samples.

RI 8434. Characterization of Alloys Formed by Ion Implantation, by B. D. Sartwell, A. B. Campbell III, B. S. Covino, Jr., and P. B. Needham, Jr.

1980. 29 pp. 13 figs. The formation of alloyed regions near the surface of metals using ion implantation is being investigated by the Bureau of Mines as a means of providing corrosion resistance using much smaller amounts of the strategic alloying metals. Two ion implantation systems that can implant low-energy chromium, nickel, or aluminum ions into low-cost substrate materials such as iron or carbon steel have been designed and constructed. The development of the ion source, ion beam acceleration stage, mass analysis system, and target chamber are described in detail. The ion-implanted alloys have been characterized using proton-induced X-ray emission to give the total number of atoms implanted and to determine the extent of any surface contamination introduced by the ion implantation process. Research conducted at other laboratories on metallurgical applications of ion implantation is given.

RI 8435. Shaft Design in the Coeur d'Alene Mining District, Idaho—Results of In Situ Stress and Physical Property Measurements, by Michael J. Beus and Samuel S. M. Chan. 1980. 39 pp. 19 figs. This Bureau of Mines report describes field investigations conducted in the Coeur d'Alene mining district of Idaho to obtain data on rock stress and physical properties. The resulting information has been utilized as input to detailed finite-element analyses to establish structural design criteria for deep-vein mine shafts. Measurement techniques include the Council for Scientific and Industrial Research biaxial and triaxial strain cells, the U.S. Geological Survey solid-inclusion probe, and the Colorado School of Mines dilatometer. Physical property testing was conducted in the laboratory on core obtained from each test site. Limited in situ physical property tests were also conducted. Reasonable success was obtained with the CSIR equipment, which was considered the most suitable for stress measurement in the study area. Test sites ranged in depth from 1,200 to 7,700 feet and are described in detail. The stress data were reduced by least-squares linear regression techniques to enable prediction of vertical and horizontal stresses to 7,500 feet. Ratios between the horizontal stresses as utilized for shaft design varied considerably, and a hydrostatic condition is the exception, based on Bureau measurements. Physical properties also varied widely, due to the complex geologic structure. Analyses of the data in terms of the tectonic history of the area show reasonable correlation. Data from previous rock mechanics investigations from the Coeur d'Alene district were also compiled and presented as part of this report to justify any generalizations regarding stress conditions and physical properties of the district as a whole.

RI 8436. Synergism in Polyethylene Oxide Dewatering of Phosphatic Clay Waste, by A. G. Smelley and B. J. Scheiner. 1980. 18 pp. 10 figs. As part of research conducted in its mission to effect pollution abatement, the Bureau of Mines, U.S. Department of the Interior, is developing a dewatering technique that allows for disposal of phosphatic clay wastes, for reuse of water now lost with clays, and for reclamation of mined land. The technique utilizes a high-molecular-weight nonionic polyethylene oxide polymer (PEO) that has the ability to flocculate and dewater phosphatic clay wastes. A synergistic flocculation study was made to determine whether a portion of PEO could be replaced by other reagents. Several groups of reagents were tested: (1) those that increased the zeta potential of the phosphatic clay wastes; (2) those capable of hydrogen bonding; and (3) those which flocculated the phosphatic clay waste. Reduction in PEO consumption occurred only with addition of those reagents able to flocculate the slime. The use of natural guar gums resulted in a lower PEO requirement and also yielded a dewatered product of higher solids content, 43 to 45 percent, versus 33 to 35 percent obtained with PEO alone. 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 8437. A Continuous Dielectric Separator for Mineral Beneficiation, by C. E. Jordan, G. V. Sullivan, B. E. Davis, and C. P. Weaver. 1980. 18 pp. 9 figs. Under its program of advancing minerals technology, the Federal Bureau of Mines has invented a laboratory apparatus for continuous separation of minerals based on differences in dielectric properties. The separator consists of a rotating drum electrode and a wire screen electrode positioned 3 mm apart. A high voltage applied across the electrodes that are immersed in a dielectric fluid produces a high-gradient electric field. The high-dielectric-constant (K) minerals are attracted to and conveyed through the separator by the rotating drum electrode, while the low K minerals settle through the screen electrode. Several design and operating parameters, such as electrode configurations, the dielectric liquid and its dielectric constant, electrical voltage and frequencies, feed rates, and particle sizes were studied. In addition, 28 different mineral mixtures were tested with the dielectric separator. In typical tests, a sample of rutile and quartz gangue containing 10-percent rutile was concentrated to 62-percent rutile with 94-percent rutile recovery. A second-stage dielectric separation of the rutile concentrate produced a 92-percent-rutile concentrate. The overall rutile recovery for the two-stage dielectric separation was 86 percent. 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 8438. An Environmental Evaluation of Polyethylene Oxide When Used as a Flocculant for Clay Wastes, by Jalna R. Zatko. 1980. 13 pp. 6 figs. The Bureau of Mines, U.S. Department of the Interior, has developed a novel method of flocculation dewatering of phosphatic clay wastes using polyethylene oxide as the flocculant. Research was conducted to determine whether ethylene oxide gas was present in the air in the vicinity of disposed waste materials which had been flocculated with polyethylene oxide. Samples of clay waste materials containing polyethylene oxide were prepared in stoppered glass bottles in simulated disposal environments. Gaseous samples, removed over a 75-day period using an airtight syringe, were injected into a gas chromatograph that was capable of separating ethylene oxide from air. The presence of ethylene oxide gas was not detected in any sample. To determine possible degradation products of polyethylene oxide, the properties and reactions of ethylene oxide and its polymers were reviewed. Based upon the literature survey and experimental study, it was concluded that adverse environmental effects were not likely to result from the use of polyethylene oxide for flocculating phosphatic clay waste products. 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 8439. Reinforcement Mechanisms of Untensioned Full-Column Resin Bolts. by August J. Kwitowski and Lewis V. Wade. 1980. 37 pp. 31 figs. This Bureau of Mines report describes how the reinforcement mechanisms of untensioned, full-column resin bolts were determined during one underground study. Both axial and transverse shear loadings were identified for two instrumented resin bolts that replaced standard resin bolts in an operating room-and-pillar mining section. The strain responses of resin bolt steel cores to local axial and transverse shear loadings are described. This information was obtained from laboratory testing of resin bolts installations; it was also used to analyze the data from the underground test.

RI 8440. Stress Distribution Around Resin-Grouted Bolts, by Daryl E. Radcliffe and Raymond M. Stateham. 1980. 39 pp. 33 figs. Ninety-seven roof bolts were instrumented with strain gages and resin-grouted in three areas of the Bear coal mine, Somerset, Colo., by the Bureau of Mines. Measurements taken with these instruments indicate roof support is achieved through a combination of point suspension and resistance to vertical and horizontal stresses caused by localized shearing in the roof. The localized shearing results in bending of the bolts, yielding due to high vertical stresses, and the transfer of high loads to the bolt head or plate.

RI 8441. Slimes Consolidation at the Henderson Mine, by R. H. Sprute and D. J. Kelsh. 1980. 20 pp. 9 figs. Underground accumulations of slimes in the Henderson mine are routed to two large collection pits where they are dewatered and consolidated by application of direct current. Densified material is then removed to ore cars by rubber-tired front-end loaders and transported out of the mine. This Bureau of Mines report describes the electrical dewatering installation and compares its efficiency of operation with that predicted from preliminary laboratory studies performed by the Bureau. Direct current from a 150-kw rectifier (applied for 44 hours at 400 amperes and 65 to 70 volts) converted slimes containing 25.3 percent solids to material ranging from 44 to 65 percent solids. Better results can be expected if the ramp and front sections of the pits are treated separately, using higher current density.

RI 8442. Low-Temperature Heat Capacities and High-Temperature Enthalpies of Chiolite ($Na_5Al_3F_{14}$), by J. M. Stuve and M. J. Ferrante. 1980. 8 pp. 2 figs. Low-temperature heat capacities of chiolite ($Na_8Al_3F_{14}$) were determined by adiabatic calorimetry in the temperature range 5.8 to 300 K. The derived standard entropy (S°, 298.15) was 115.6 ± 0.2 cal/deg-mole. High temperature enthalpies relative to 298.15 K were obtained by precision drop calorimetry up to 1,000 K. Tables of experimental data and related thermodynamic functions are given for the temperature range of experimental observations.

RI 8443. Shape-Casting Titanium in Olivine, Garnet, Chromite, and Zircon Rammed and Shell Molds, by R. K. Koch and J. M. Burrus. 1980. 33 pp. 18 figs. In seeking substitutes for such critical metals as chromium, cobalt, and nickel, the Bureau of Mines investigated techniques for shape-casting titanium in rammed sand molds. Castings were made in olivine, garnet, chromite, and, for comparison, zircon. It was found that commercial-grade castings up to 31 lb (maximum capacity of furnace) could be made in zircon or olivine molds if a zirconia mold wash was used. Castings up to 4 lb could be made in chromite molds, but heavier castings suffered from some mold-metal reaction. Garnet molds were found to be unsatisfactory for castings of all sizes because of gas blows and rough surfaces. In other tests shell castings of acceptable quality were produced in water-glass-bonded zircon and olivine molds up to weights of 8 lb, but chromite molds were unsatisfactory because rough casting surfaces were caused by mold-metal reaction. Unlike the currently used commercial processes, neither the rammed-sand nor the shell-molding processes developed by the Bureau of Mines generate noxious fumes at any step.

RI 8444. Helium—Its Relationship to Geologic Systems and Its Occurrence With the Natural Gases, Nitrogen, Carbon Monoxide, and Argon, by Claude A. Tongish. 1980. 176 pp. 9 figs. This Federal Bureau of Mines report presents information on the accumulation and distribution of helium in U.S. natural gas reservoirs. The investigation concerns the relationship or association of helium with geographic location, geologic age, reservoir depth, nitrogen, carbon dioxide, and argon. Although helium is a minor constituent in natural gas, these data show that certain conditions make some reservoirs satistically more favorable than others for the accumulation of helium. The report is based on gas analysis information collected by the Bureau from 1917 to 1974 from 10,086 gas samples, representing 6,455 reservoirs in 35 States. The occurrence of helium in the reservoirs was 11.5 percent with less than 0.005 percent of helium, 70.9 percent with 0.005 through 0.29 percent of helium, and 17.6 percent with 0.30 percent or more of helium in the gas. Results of the various correlations are presented in tables and charts. Relationships have also been determined quantitatively by measures of correlation. The statistical data can be used to determine the environment under which reservoirs with high-helium contents are most likely to occur. These data can be used with other information for predicting the future helium resources of the United States.

RI 8445. Preparing Rare Earth-Silicon-Iron-Aluminum Alloys, by J. D. Marchant, E. Morrice, B. P. Herve, and M. M. Wong. 1980. 10 pp. 1 fig. As part of its mission to assure the maximum recovery and use of the Nation's mineral resources, the Bureau of Mines investigated an improved procedure for producing rare earth-silicon alloys. For example, a charge consisting of 681 grams of mixed rare-earth oxides, 309 grams of ferrosilicon (75 wt-pct Si), and 182 grams of aluminum metal along with a flux consisting of 681 grams of Ca0 and 45 grams of Mg0 was reacted at 1,500° C in an induction furnace. Good slag-metal separation was achieved. The alloy product contained, in weight-percent, 53 RE, 28 Si, 11 Fe, and 4 Al with a rare earth recovery of 80 pct. In current industrial practice rare earth recoveries are usually about 60 pct in alloy products that contain approximately 30 wt-pct each of rare earths and silicon. Metallurgical evaluations showed the alloys prepared in this investigation to be as effective in controlling the detrimental effect of sulfur in steel and cast iron as the commercial rare earth-silicon-iron alloys presently used in the steel industry.

RI 8446. Experimental Processing of Salt Slags From an Aluminum Dross Furnace, by Michael J. Magyar, Robert S. Kaplan, and Harry V. Makar. 1980. 26 pp. 10 figs. The Federal Bureau of Mines has

developed a hydrometallurgical method to recover aluminum, aluminum oxide, and fluxing salts from aluminum salt slags. The slag is leached with water at room temperature to produce a saturated brine slurry. Screening of the slurry yields an aluminum-rich fraction that can be returned to the dross furnace. The remaining slurry is vacuum filtered, yielding a clear brine solution and an aluminum oxide filter cake. Evaporation of the clear filtrate produces a high-purity fluxing salt for reuse in the dross furnace. Over 80 pct of the metallic aluminum is recovered in the aluminum-rich oversize fraction, while essentially all the fluxing salts are recovered by evaporation. This report contains the final results of an investigation on a process research unit scale, an economic evaluation of the method, and recommendations to further improve the process.

RI 8447. Atmospheric Corrosion Resistance of Steels Prepared From the Magnetic Fraction of Urban Refuse, by Stephen D. Cramer, John P. Carter, and Bernard S. Covino, Jr. 1980. 32 pp. 13 figs. The Bureau of Mines conducted a study in which the magnetic fraction of urban refuse was used as melting stock in the preparation of high-strength, low-alloy and carbon steel. Product steels, made from incinerated steel can scrap, nonincinerated-nondetinned steel can scrap, nonincinerated-detinned steel can scrap, and dilutions of these scraps with No. 1 heavy melting scrap, were used in continuing tests in industrial, rural, and marine environments to determine the effect of residual elements and atmospheric pollutants on their atmospheric corrosion resistance. The respective commercial steels were exposed at the same time to establish baseline corrosion data for the test sites. Weight-loss data are reported for atmospheric exposures of 0.5, 1.0, 1.5, and 3.8 years. The marine environment was the most corrosive; the industrial environment was the least corrosive. The atmospheric corrosion resistance of the carbon steel was improved 25 pct by using incinerated scrap and nonincinerated-nondetinned scrap in the steelmaking process. In no case was the atmospheric corrosion resistance of carbon steel degraded by using the magnetic fraction of urban refuse as melting stock. The presence of sulfur in the corrosion film was the most important factor affecting the corrosion resistance of the steels. With increasing sulfur concentration, the rate of the corrosion reaction was reduced and the corrosion film became more protective. The residual elements in the product steels most responsible for improving corrosion resistance were copper and tin. These elements tended to increase the concentration of sulfur in the corrosion film. At the levels present in the product steels, Cr, Ni, and Pb had no observable effect on the corrosion resistance of the steels.

RI 8448. Experiments in Hot-Rolling and Forging of Ductile Cast Iron, by L. A. Neumeier, B. A. Betts, and R. L. Crosby. 1980. 36 pp. 14 figs. The Bureau of Mines investigated hot-rolling and forging characteristics of experimental ductile iron castings, both sand and permanent-mold, made with charges containing up to 70 pct foundry pig iron and 95 pct steelmaking pig iron. Between 1,550° and 1,950° F, most castings could be rolled to 90-pct reduction or forged to 70-pct reduction without serious cracking. Charge and composition have less bearing on workability than on subsequent properties. Permanent mold castings could be worked as readily as sand castings at 1,750° and 1,950° F. Plasticity improved with temperature. Small billets were also forged cold to 50-pct reduction without cracking. With equivalent nodularity, composition affects properties of wrought materials by altering matrix structure and strength. Properties vary with reduction and improve with increasing working temperature. Rolled material has high strength and anisotrophy, and low ductility, particularly in the transverse direction. Annealing reduces strength and improves ductility, but anisotropy persists. At 70-pct reduction, impact resistance in the longitudinal direction is about twice that in the transverse. Annealing roughly doubles impact resistance. Deformation enhances damping capacity. The feasibility of die-forging and bar-rolling of ductile iron was evaluated in trial tests conducted under a Bureau contract. Although workability and ductility of ductile iron are inferior to those of steel, more advantage could be taken of ductile iron's plasticity to work rough shapes to final dimensions.

RI 8449. Scrubbers for Dust Control: A Comparison of Six Medium-Energy Use Types, by Edward F. Divers and Joseph T. Janosik. 1980. 29 pp. 7 figs. This Bureau of Mines report describes the results of a program to develop small, rugged scrubbers with high dust collection efficiency for use in underground coal mines. The Bureau's Pittsburgh (Pa.) Research Center has developed and assisted in the development of several types of improved scrubbers that are especially suitable for various underground mining applications. Research efforts concentrated on reducing the size, power, and water consumption of these scrubbers, while optimizing their dust collection efficiency. Fractional dust collection efficiency, air volumetric range, size, power, water consumption, and application guidelines for each type are described. Air pressure differentials ranged between 2- and 30-inches water column (wc). The dust collection efficiency of six scrubbers—a venturi, two flooded-fibrous-bed, a venturi-impaction plate, a wetted-fan, and a rotating flooded-bed—were compared. The rotating flooded-fibrous-bed and the stationary flooded-fibrous-bed scrubbers showed the highest coal dust collection efficiency. Test results show that these scrubbers can generally achieve respirable size coal dust collection efficiencies in the high 90-pct range required to reduce both long- (8-hour) and short-term coal mine dust concentrations below Federal requirements.

RI 8450. Behavior of Wood Fires in Model Tunnels Under Forced Ventilation Flow. Tests With Untreated Wood, by C. K. Lee, R. F. Chaiken, J. M. Singer, and M. E. Harris. 1980. 58 pp. 37 figs. This Bureau of Mines report presents results from experimental studies on wood fires in a laboratory-scale tunnel network. Experimental measurements include ignition delay time, flame spread rate, ventilation air and gas flow rates, wood temperature, gas temperature, pressure and composition, thermal flux, and smoke particulates. These measurements form a data base for fire-scaling studies and provide information on various fire processes, such as flow interacting between ventilation air and fire, fire throttling and reverse flow, and duct fire energetics. Results show how hazards of duct fires relate to the development of (1) asphyxiating and toxic fumes, (2) explosive gas mixtures, (3) throttling of ventilation air, and (4) high-temperature combustion products. Such fire hazards should be carefully considered when testing flammabilities of materials used in a confined underground mine environment.

RI 8451. Thermodynamic Properties of Petalite ($Li_2Al_2Si_8O_{20}$), by K. O. Bennington, J. M. Stuve, and M. J. Ferrante. 1980. 20 pp. 2 figs. The thermo-

dynamic properties of petalite ($Li_2Al_2Si_8O_{20}$) were determined by the Bureau of Mines. The enthalpy of formation was determined by hydrofluoric acid solution calorimetry. The values from the elements and from the oxides are

$$\Delta H°_{f298.15} = 2{,}335.8 \pm 3.0 \text{ kcal/mole},$$

and

$$\Delta H°_{298} \text{ (from oxides)} = -50.60 \pm 1.20 \text{ kcal/mole}.$$

Low-temperature heat capacities were determined by adiabatic calorimetry from 10.69 to 302.11 K. The derived standard entropy is

$$S°_{298.15} = 111.0 \pm 1 \text{ cal/deg-mole}.$$

Enthalpy increments above 298 K were measured by copper block calorimetry from 298 K to 1,193.6 K. The various experimental data were combined with other data from the literature to calculate the Gibbs energies of formation and equilibrium constants of formation over the temperature range of the measurements. Tables of enthalpies of formation and Gibbs energies of formation are given as a function of temperature from the elements and constituent oxides. The Gibbs energy of formation is

$$\Delta G°_{f298.15} = 2{,}203.8 \text{ kcal/mole}.$$

RI 8452. Chemical and Physical Characterization of Amosite, Chrysotile, Crocidolite, and Nonfibrous Tremolite for Oral Ingestion Studies by the National Institute of Environmental Health Sciences, by William J. Campbell, Charles W. Huggins, and Ann G. Wylie. 1980. 63 pp. 33 figs. The Federal Bureau of Mines provided five test materials—amosite, short- and long-fiber chrysotile, crocidolite, and nonfibrous tremolite—to the National Institute of Environmental Health Sciences (NIEHS) for studies on the biological effects of orally ingested asbestos-related materials. An interagency agreement between the Bureau and NIEHS made possible this program to characterize these test materials. The Bureau in turn received support through contracts with the Ontario Research Foundation for the milling of amosite and crocidolite, and with the University of Maryland for microscopic measurements. The five test materials, which were supplied in quantities of 960 to 1,200 pounds each, were characterized by chemical-instrumental analysis for elemental composition, surface area, density, X-ray diffraction, infrared spectroscopy, thermogravimetric analysis, mineralogy, and particle size analyses. Particle size distributions were emphasized because of the current theories relating adverse biological effects to length-width characteristics of durable elongated particles. The work upon which this report is based was done under an agreement between the Bureau of Mines, U.S. Department of the Interior, and the National Institute of Environmental Health Sciences.

RI 8453. Documentation and Analysis of a Massive Rock Failure at the Bautsch Mine, Galena, Ill., by Jack Touseull and Charles Rich, Jr. 1980. 49 pp. 29 figs. On November 15, 1972, the Bautsch mine, a lead-zinc mine in Paleozoic dolomites, experienced a massive rock failure involving 3 to 5 million tons. Because this failure was large and extended to the surface, it was included in the Federal Bureau of Mines investigations on "Massive Rock Failures." Analysis of the rock mechanics and mode of failure revealed that failure at the Bautsch mine was the result of the interrelationship of many factors. Factors related to the failure were found to be external and internal to the mining environment. Unlike internal factors, external factors were not apparent and, therefore, many external factors were investigated; some of which are not normally considered in rock mechanics analyses. External and internal factors determined to be of significant importance were (1) precipitation, (2) fractures, (3) plastic clay layer, (4) topography, (5) rock alteration, (6) bedding, and (7) mining zone dimensions. Because of the conditions at the mine, failure could have been predicted without extensive instrumentation. Application of basic geologic and engineering principles to the internal and external factors could have predicted failure. Alternately, failure would, in all probability, have been delayed by years if, after 1962, mining had been curtailed in the area of failure.

RI 8454. Utilizing the Magnetic Fraction of Raw Refuse With Shredded Automobile Scrap in Cupola Gray Iron, by V. R. Spironello and W. M. Mahan. 1980. 19 pp. 7 figs. The Bureau of Mines is involved in research directed toward the utilization of municipal solid waste. One of the primary objectives is the recycling of the magnetic fraction of municipal solid waste (raw refuse). This is consistent with one of the Bureau's goals, which is to minimize the requirements for mineral commodities by maximizing metals recovery from secondary domestic resources. In this investigation, cupola trials were made using combinations of refuse scrap with shredded automobile scrap under basic and acid slag practices. Furnace operating information and the behavior of alloying and tramp elements was obtained. The research showed that it is possible to utilize up to 60 percent refuse scrap in the cupola under basic practice and 30 percent under acid practice. Aluminum in refuse scrap, present in bimetallic cans, increased the recoveries of silicon and manganese charged to the cupola. Increased use of refuse scrap provided iron of lower sulfur. The alumina resulting from oxidation increased the slag volume. The aluminum and tin contents of the iron increased with increasing levels of refuse scrap in the charge. Lead was not a problem with respect to contamination of the iron. In basic practice, operation of the cupola was satisfactory since all slags were adequately fluid. In acid practice, operation became troublesome above the 45-percent level. Under both practices, the cupola iron melting rate decreased. Particulates in scrubber water and stack condensate samples contained lead, zinc, and tin, and the dust load increased. The tensile and transverse strengths of the iron produced under both practices are reported.

RI 8455. Characterization of Thin Films and Solid Surfaces Using Proton-Induced X-Ray Emission, by Bruce D. Sartwell and Arthur B. Campbell III. 1980. 22 pp. 10 figs. The Bureau of Mines is using characteristic X-rays produced by proton bombardment of a solid surface to provide quantitative compositional analyses of surface layers of metals. An integral X-ray yield equation has been developed that quantitatively relates the measured X-ray yield to the thickness of thin films ranging from less than a monolayer to several thousand angstroms. The use of the integral yield equation is demonstrated for the growth of a thin film by vacuum evaporation. Results are presented that show how proton-induced X-ray emission (PIXE) has been used to determine the oxidation kinetics of iron that had been implanted with several different species of heavy ions. The sensitivity of PIXE for the measurement of very-thin-film growth kinetics is demonstrated from studies of the effect of fractional monolayer coverages of sulfur on the initial oxidation kinetics of iron. Results are also presented in which PIXE has been used to study the redistribution of alloying

elements in components of a gas turbine that had fractured due to corrosion fatigue. By combining PIXE with low-energy ion sputtering, quantitative composition depth profiles of surface layers are obtained. Examples are presented for the profiling of iron samples implanted with 25-kev nickel ions and for a platinum coating on an Fe-5Cr substrate.

RI 8456. Partial Pressures of Gaseous HCl and H_2O Over Aqueous Solutions of HCl, $AlCl_3$, and $FeCl_3$, by N. A. Gokcen. 1980. 18 pp. 18 figs. Equilibrium partial pressures of gaseous HCl and H_2O over aqueous binary and ternary solutions of HCl and $AlCl_3$ were calculated or estimated in the range of 20° to 110° C, and up to saturation with $AlCl_3 \cdot 6H_2O$. The results were extended to solutions containing less than 10 wt-pct $FeCl_3$ by assuming that $FeCl_3$ and $AlCl_3$ are equivalent on the molar basis, since both salts have trivalent cations with a common anion. The ionic activity coefficient of HCl and the equilibrium constant for dissolution of gaseous HCl were also computed. This research is part of the effort by the Bureau of Mines, U.S. Department of the Interior, to provide thermodynamic data to expand the technology base relevant to the extraction of alumina from nonbauxitic domestic raw materials.

RI 8457. Pneumatic Concentration of Mica, by C. E. Jordan, G. V. Sullivan, and B. E. Davis. 1980. 24 pp. 7 figs. The Bureau of Mines is conducting research into the pneumatic recovery of coarse mica and has used this method to produce mica concentrates that contain more than 90 percent mica. This research is being carried out pursuant to the Bureau's objective to develop technology that will help maintain an adequate supply of minerals and metals to meet national economic and strategic needs. Researchers used a Bureau-designed system of crushers, screens, and zigzag air classifiers to concentrate coarse liberated mica particles from mica-bearing materials. This pneumatic system was used to concentrate four mica ores from Arizona, North Carolina, and South Dakota and three waste tailings from Alabama, Georgia, and South Dakota. Using these samples, it was demonstrated that plus 65-mesh size mica can be effectively recovered by the pneumatic method. Not only were the concentrates high in mica content; it was also demonstrated that this method can be used to recover up to 78 percent of the mica that was originally contained in the samples. Because it is a dry concentration method, the pneumatic beneficiation technique may be advantageous in areas where water resources are limited. 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 8458. Recovery of Gold From Arsenopyrite Concentrates by Cyanidation-Carbon Adsorption, by H. J. Heinen, G. E. McClelland, and R. E. Lindstrom. 1980. 10 pp. 1 fig. The Bureau of Mines investigated a cyanidation-carbon adsorption technique for extracting gold from arsenopyrite concentrates. Agitation leach experiments were conducted on 85-pct minus 35-mesh gravity concentrates containing 21.8 oz gold and 6.4 oz silver per ton. Results obtained in leaching the concentrates showed that 96.9 pct gold and 90.7 pct silver extraction could be achieved in 96 hours of agitation. Gold and silver were recovered from the resulting pregnant solution by exposure to granular activated carbon in a countercurrent system. Carbon loadings of 2,556 oz of gold and 502 oz of silver per ton were achieved. These loadings are significantly higher than heretofore thought practical.

RI 8459. Three Coal Mine Gob Degasification Studies Using Surface Boreholes and a Bleeder System, by S. D. Maksimovic and Fred N. Kissell. 1980. 10 pp. 6 figs. The use of vertical surface degasification boreholes with bleeder systems and the use of a timbered bleeder system to degasify gob areas were studied by the Bureau of Mines. This report describes three gob degasification studies conducted in the Pittsburgh coalbed. One study was conducted to determine the number of panels degasified with one large borehole. The study showed that the borehole provided degasification for three panels. Another study was conducted during the retreat of a 35-acre panel with a single-entry and a two-entry bleeder system and a large surface borehole. A major portion of methane emitted from the panel was carried away by the borehole, leaving the bleeder entries relatively free of methane. The last study was made to determine the effectiveness of a timbered bleeder system. The bleeder entries successfully degasified the gob area when enough entries were available and adequate pressure was available to force the air through roof falls.

RI 8460 Application of Thermal Neutron Capture-Gamma Ray Analysis to Oxidized Taconite Beneficiation Process Slurries, by Franklin B. W. Woodbury. 1980. 71 pp. 17 figs. The Bureau of Mines undertook the development and evaluation of a system to provide a simultaneous, on-line determination of both iron and silica in iron ore beneficiation streams as part of a program to improve the efficiency to mineral separation processes. Californium-252 (252-Cf) was the neutron source used in the system for measuring the amounts of silica and iron in bulk slurries by thermal neutron capture-gamma ray spectra analysis. The theory of thermal neutron capture-gamma ray reactions and their potential application to mineral processing stream analysis is discussed. The prototype system and supporting software developed by the Bureau is described. During the initial phase of the work, both simulated and actual pilot plant slurries were investigated using a 60- to 32-μg 252-Cf neutron source. The percent solids of the slurries ranged from 2 to 40 percent and the silica and iron content ranged from 1.5 to 83 percent and from 10 to 65 percent, respectively. Accuracy of the determination of the components in the solids was dependent upon the percent solids in the slurry.

RI 8461. Monitoring Taconite Process Streams With Thermal Neutron Capture-Gamma Ray Analysis, by Franklin B. W. Woodbury. 1980. 24 pp. 14 figs. The Bureau of Mines, as part of its goal of helping maintain an adequate supply of minerals to meet national economic and strategic needs, is evaluating alternative technologies to treat oxidized taconites. Since process control is an essential element in the application of these process technologies, research was performed on a prototype monitoring system utilizing a Californium-252 (252-Cf) neutron source and a thermal neutron capture-gamma ray spectra analysis method to measure the amount of iron and percent solids in process slurries. The prototype system was used to monitor the concentrate and tailing streams in a 900-lb/hr flotation pilot plant during continuous around-the-clock tests. The iron content of the process slurries was determined by measuring the total peak areas under the capture spectrum peaks at 7.626–7.632 MeV, the associated

escape peaks at 7.136–7.122 and 6.626–6.612 MeV, and the iron doublets at 4.900 and 4.998 MeV. A potential method for determining the percent solids in process slurries using the 2.22-MeV hydrogen capture peak is discussed. Results of this work demonstrate a potential method for providing process control parameters using the data from thermal neutron capture-gamma ray reactions.

RI 8462. Recovery of Rutile From a Porphyry Copper Tailings Sample, by T. O. Llewellyn and G. V. Sullivan. 1980. 18 pp. 3 figs. The Bureau of Mines conducted batch-scale tests on a sample of porphyry copper mill tailings as part of a study to determine the feasibility of rutile recovery from this source. The tailings that were tested contained 0.75 percent titanium dioxide (TiO_2), with about two-thirds of the TiO_2 values occurring as rutile. Mineralogical studies indicated that about one-half of the TiO_2 content could be considered recoverable. Beneficiation studies of the tailings showed that best flotation results were obtained when sulfides and carbonates were removed by bulk flotation prior to rutile flotation. Rutile flotation was most effective when a petroleum sulfonate collector was used in an acid circuit. From this basic method of flotation, two alternative procedures were developed. The first procedure was to size and grind the tailings to minus 200 mesh; deslime the total pulp; and then float the sulfides, carbonates, and rutile. The second procedure was the same, except that it did not include sizing and grinding. Flotation of the sized and ground tailings yielded rutile concentrates containing 43.1 percent TiO_2 and 75.7 percent of the recoverable TiO_2. Rutile concentrates floated from the tailings that were deslimed but not ground contained only 34.7 percent TiO_2 and 69.4 percent of the recoverable TiO_2. The work upon which this report is based was done under an agreement between the Bureau of Mines, U.S. Department of the Interior, and the University of Alabama.

RI 8463. Absorption of Radium and Thorium From New Mexico Uranium Mill Tailing Solutions, by H. R. Beard, H. B. Salisbury, and M. B. Shirts. 1980. 14 pp. 1 fig. The Bureau of Mines investigated the absorption of radium and thorium from waste uranium leach liquor by clays and other materials. This work was conducted in support of the Bureau's goal of minimizing the environmental conflicts, impacts, and occupational hazards associated with mining and milling operations. Tailing and soil samples from New Mexico were evaluated for their potential to absorb radium and thorium from tailing liquors. Absorption ranged from 0 to 97 pct for radium and 0 to 60 pct for thorium. Some samples that readily absorbed radium were contacted with various salt solutions that could be present in tailing solutions to determine whether desorption would be a potential problem. The desorption of radium ranged from 0 to 75 pct. An alpha spectrometric method was used to determine the radium and thorium concentrations in the solutions and solids.

RI 8464. Practical Ignition Problems Related to Intrinsic Safety in Mine Equipment. Four Short-Term Studies, by E. L. Litchfield, T. A. Kubala, T. Schellinger, F. J. Perzak, and D. Burgess. 1980. 18 pp. 10 figs. Four short-term studies of practical ignition problems were undertaken and completed during the course of the Bureau of Mines project "Development of Specifications for Intrinsically Safe Equipment." Conclusions were as follows: (1) the most easily ignitible mixture of propane-air in a PTB break flash apparatus is approximately 5.2 percent propane; (2) miniature lamp bulbs to be used in intrinsically safe circuits are about as incendive to coal dust-air as to methane-air and should be tested in gas mixtures containing about 7.0 to 7.5 percent methane; (3) the sodium amalgam contained in high-pressure sodium lamps does not present an ignition hazard for coal dust or methane, where the lamps contain no more than 30 milligrams of amalgam; (4) the maximum allowable surface temperature of permissible electrical enclosures should remain at 150° C despite efforts by industry groups to raise the value to 200° C.

RI 8465. Well Engineering and Sampling Variables in the Evaluation of Geobrines, by W. D. Riley, R. P. Walters, F. X. McCawley, G. R. Conner, and P. B. Needham, Jr. 1980. 20 pp. 12 figs. The U.S. Department of the Interior, Bureau of Mines, has been conducting minerals recovery research in support of the Nation's geothermal program since 1974. The Bureau's program of laboratory and field studies has focused on determining the materials of construction for geothermal resource recovery plants and on the recovery of mineral values from the geobrines. An analytical program has been conducted at the Avondale Research Center to determine the chemical constituents of some high- and low-salinity geobrines found in the Imperial Valley of California. Data are reported for the early stages of brine production of four geothermal wells—the low-salinity, medium-enthalpy brines from the East Mesa Known Geothermal Resource Area (KGRA), Mesa 6–1, and 6–2, and the high-salinity, high-enthalpy brine from the Salton Sea KGRA, Magmamax 1 and Woolsey 1. The reported results indicate the importance of the operating and engineering history, the operating parameters during sampling, and the method of sampling in order to evaluate the chemical analyses.

RI 8466. Effect of Additives on Sintering of Silicon Nitride-Alumina Compositions, by B. W. Jong. 1980. 16 pp. 2 figs. As part of the Bureau of Mines program to develop substitute or improved performance refractory materials for metallurgical applications, the Tuscaloosa Research Center has evaluated the effect of additives on sintering and strength properties of sialon (silicon aluminum oxynitride) compositions fabricated by a conventional powder metallurgy technique. Additions of Y_2O_3, Gd_2O_3, CeO_2, MgO, ZrO_2, $ZrSiO_4$, and $MgAl_2O_4$ to a sialon composition containing 70 pct β-Si_3N_4 + 30 pct α-Al_2O_3 increased sintered densities by as much as 50 pct over densities of undoped material. The studies also indicated that sintered densities reached a maximum between 20 and 30 mole-pct α-Al_2O_3 when a series of sialon compositions of α-Si_3N_4, having 6.7 to 57.9 pct α-Al_2O_3, were doped with Y_2O_3, Gd_2O_3, and MgO. In studies to establish the effect of the crystalline phase of the silicon nitride and alumina used, tests were made using α- and β-Si_3N_4 and α- and γ-Al_2O_3 as starting materials. The tests indicated that when using an addition of 5 wt-pct Y_2O_3, best results were obtained with a sialon composed of 74.4 mole-pct α-Si_3O_4 and 25.6 mole-pct γ-Al_2O_3. In other tests made with this sialon composition modulus of rupture values of 28,120 and 29,500 psi at 25° C, and 23,520 and 16,850 psi at 1,400° C, were obtained when doping with 5 wt-pct $ZrSiO_4$ and ZrO_2, respectively. 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 8467. Correlation of the Fibrous Aerosol Monitor With the Optical Membrane Filter Count Technique, by Steven J. Page. 1980. 21 pp. 6 figs. The Bureau of Mines used fiber-laden air to test two identical fibrous aerosol monitors (FAM) in order to establish the FAM-optical count correlation. The FAM is a unique instrument developed by GCA Corp. (GCA) to measure real-time fibrous aerosol concentrations. It will also respond to particulates that have sufficient shape irregularities to possess fiber characteristics such as the 3:1 length:diameter (L:D) aspect ratio. Results of the Bureau's laboratory tests showed that the FAM response is linearly correlated to concentration data obtained using the optical membrane filter count technique approved by the National Institute for Occupational Safety and Health (NIOSH), U.S. Department of Health, Education, and Welfare. A plot of the FAM-optical count correlation showed that FAM concentration readings are generally well within ±25 pct of the optical membrane filter count. Initial tests to estimate the best ratio control setting of the FAM for 5-μm fiber-length discrimination were performed using one instrument only (the ratio control setting determines the minimum threshold fiber length that will be detected by the FAM). The estimated setting was then used to correlate both FAM units. The result was a 65-pct difference in correlation between the two units. It appears that the major factor responsible for this difference was the internal adjustment of the photomultiplier detector sensitivity for each of the two FAM units.

RI 8468. A Laboratory Test To Evaluate the Resistance of Refractories to Molten Slags, by J. R. Cobble and L. Y. Sadler III. 1980. 13 pp. 7 figs. As part of the Federal Bureau of Mines project to develop new or improved materials for metallurgical furnace applications, the Tuscaloosa (Ala.) Research Center has conducted research to develop a reproducible laboratory test for evaluating the resistance of refractories to molten slags. Tests were conducted with a slag representative of slag used to produce mineral wool. A rotating cylindrical furnace was lined with the brick being tested, and it was operated at temperatures up to 1,660° C for periods ranging from 8 to 32 hours. The effects of such variables as slag temperature, rotational velocity, charge rate, and contact time on refractory erosion were determined. The research demonstrated the reproducibility of the test procedure developed. 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 8469. The Theory of Flammability Limits. Conductive-Convective Wall Losses and Thermal Quenching, by Martin Hertzberg. 1980. 25 pp. 5 figs. The concept of limit burning velocities, formulated in an earlier Bureau of Mines report (RI 8127) is applied to the problem of flame propagation through tubes of finite size. The limit burning velocity for conductive-convective wall-loss quenching (process b) is $(S_u)_b = \frac{\alpha Pe}{2r_o}$, where the proper choice of critical Peclet constant, Pe, is determined mainly by the ratio of contact-perimeter loss area to flame-zone cross-sectional area. This ratio of loss area to propagation area relates to the shape of the flame front and its control by buoyancy and by boundary conditions. The comparison of $(S_u)_b$ with previously defined limit velocities for systems mixed by natural convection allows one to assess the influence of tube dimensions and boundary constraints on the "true" or earthly limits for the three directions of propagation. The flame quenching caused by inert powders is shown to be similarly described in terms of a limit burning velocity, $(S_u)'_b$. The tube's surface-to-volume ratio ($\sim 1/r_o$) is simply replaced by the powder's surface area per unit volume of the flammable mixture. Thermal loss quenching by these "internal walls" occurs at a critical Peclet constant somewhat higher than that observed for tubes, and the problem is complicated by the finite heat capacities of the powders and particle lag effects in the flame front.

RI 8470. Iron-Base Alloys Strengthened by Laves Phases as Substitutes for Stainless Steels, by J. S. Dunning, M. L. Glenn, and W. L. O'Brien. 1980. 24 pp. 9 figs. One Federal Bureau of Mines research goal, to minimize requirements for domestically scarce mineral commodities through conservation and substitution, can be accomplished by utilizing more abundant elements such as iron, molybdenum, and titanium. An example of this research is the study of precipitation-hardening, iron-base alloys containing molybdenum and titanium, as substitutes for the high-tonnage stainless steels that are high in imported nickel and chromium. The precipitation-hardened iron-base alloys are strengthened by a dispersion of the ternary Laves phase, $Fe_2(Mo, Ti)$. Aluminum and chromium additions changed the solid solubility limits of molybdenum and titanium in α-iron and affected the composition of precipitating phases. A baseline composition of Fe-7Mo-2Ti was selected to study the effects of aluminum and chromium additions on the precipitation-hardening mechanism and microstructure and was also used in studies of mechanical properties and oxidation resistance. The study yielded workable, precipitation-hardening alloys, with elevated temperature strengths equivalent to or superior to types 304 and 316 stainless steels. Chromium and aluminum additions in combination were more effective in providing oxidation resistance than either addition was alone.

RI 8471. Recovery of Byproduct Heavy Minerals From Sand and Gravel Operations in Central and Southern California, by J. M. Gomes, G. M. Martinez, and M. M. Wong. 1980. 20 pp. 5 figs. The Bureau of Mines has investigated the occurrence and recovery of byproduct heavy minerals from sand and gravel operations as a means of assessing the Nation's resources. Sand samples from 63 locations in central and southern California were treated to yield heavy-mineral concentrates. The mineral compositions of the concentrates were characterized by chemical and mineralogical examinations. Additional large quantities of concentrates were prepared from selected deposits that contained significant quantities. Beneficiation studies were performed on these concentrates to recover individual mineral products. Gold was recovered by amalgamation; platinum-group metals and radioactive minerals by flotation; magnetite, ilmenite, and chromite by magnetic and high-tension separation techniques.

RI 8472. Electrolytic Reduction of Chromium (VI) and Copper Using Coke Electrodes, by H. O. McDonald, D. M. Soboroff, and A. A. Cochran. 1980. 8 pp. 3 figs. Solutions containing Cr^{6+} and sulfuric acid are used in a number of surface-finishing operations. Substantial quantities of chromium and copper are lost and pollution problems are created when the spent solutions are discarded. To minimize the undesirable environmental effects while improving sec-

ondary resource recovery technology, the Bureau of Mines is conducting research to detoxify and recover metals from these solutions. Spent etchants are treated to remove copper and reduce Cr^{6+} to Cr^{3+} in an electrolytic cell. The anodes and cathodes are granulated coke. The spent solution is continuously pumped through the electrodes. Hexavalent chromium is reduced to trivalent chromium, and copper is recovered at the cathode. Reoxidation of Cr^{3+} at the anode was not observed. The removal and recovery of copper and reduction of Cr^{6+} lessen chemical demand and increase efficiency in waste treatment operations associated with the use of these solutions.

RI 8473. Face Ventilation Measurement With Sulfur Hexafluoride (SF_6), by Robert P. Vinson, Fred N. Kissell, John C. LaScola, and Edward D. Thimons. 1980. 16 pp. 21 figs. The face ventilation measurement method developed by the Bureau of Mines involves releasing a small volume of tracer gas (SF_6) on the off-curtain side of the working face at the start of the mining cycle. At the same time, gas bottle samples are taken in the immediate return airway. The gas samples are analyzed, and a curve is drawn of SF_6 concentration versus time. From this curve, the percentage of gas removed per time is calculated. A curve showing a high percentage of the tracer gas removed in a short period would represent a well-ventilated face. The face ventilation measurement method was tested in a full-scale mine entry model. Subsequently it was used underground to evaluate the spray-fan ventilation system and in an MSHA test facility to test machine-mounted scrubbers. The method was shown to be a simple and effective way of evaluating face ventilation systems.

RI 8474. Spontaneous Combustion Susceptibility of U.S. Coals, by J. M. Kuchta, V. R. Rowe, and D. S. Burgess. 1980. 37 pp. 18 figs. The chemical and thermal criteria used for predicting the spontaneous combustion hazard are briefly reviewed and data are presented to characterize the gas desorptions and self-heating tendencies of 29 U.S. coals. Closed vessel desorption experiments showed that CO, CO_2, and CH_4 are the main gases evolved and that the CO, $CO/\triangle O_2$ index, and O_2 absorption rate increase with decreasing rank and increasing oxygen content of the coal. In this Bureau of Mines report, the effects of temperature, moisture, and other variables are discussed together with the application of the data to the complex conditions encountered in a mining environment. An important finding is that the presence of CO alone in a mine is not necessarily an indication of a self-heating reaction of the coal. Based upon experiments conducted in an adiabatic-type calorimeter, the self-heating temperatures of lignite and subbituminous coals can be as low as 30° C, whereas the bituminous coals require a temperature of about 60° C or more. The self-heating hazard is greatest when the coals are dried and exposed to a high humidity condition, apparently as a result of the "heat-of-wetting." Generally, the hazard is greatest with the western coals of the United States.

RI 8475. Recovery of Potash Feldspar From Molybdenite Tailings, by W. H. Eddy and G. V. Sullivan. 1980. 22 pp. 10 figs. The Bureau of Mines used several laboratory batch flotation schemes combined with magnetic separation to investigate the feasibility of recovering potash feldspar and glass sands from molybdenite tailings. Four molybdenite tailings or prospective tailings were used as test samples. Feldspar concentrates containing from 10.7 pct to 12.0 pct K_2O were recovered from three of the four samples. The alkali content of the fourth sample met the grade for a mixed feldspar. All the feldspar concentrates contained iron in excess of the 0.10-pct-Fe_2O_3 specification for most uses. Electron-beam microprobe examination of the feldspar concentrates showed the presence of an iron-bearing potash feldspar in quantities that were excessive with respect to most iron specifications. However, a high-quality glass sand was produced from all of the samples. The work upon which this report is based was done under an agreement between the Bureau of Mines, U.S. Department of the Interior, and the University of Alabama.

RI 8476. Producing Alumina From Clay by the Hydrochloric Acid Process, A Bench-Scale Study, by J. A. Eisele. 1980. 21 pp. 4 figs. The Bureau of Mines conducted bench-scale cyclic tests to determine the composition of recycled leach liquor in the Bureau's proposed clay/HCl leach/HCl sparge process for producing Al_2O_3 from clay. The data developed from these tests make it possible to synthesize leach liquors for predetermined steady-state operating conditions when conducting large-scale crystallization tests. The results of two sparge tests were compared. One was a 20-cycle test with a 36-pct-HCl concentration in the mother liquor; the other was a 10-cycle test with a 26-pct-HCl concentration in the mother liquor. The effect of impurity concentrations in the leach liquor on the purity of aluminum chloride ($AlCl_3 \cdot 6H_2O$) crystals was determined, but there was poor correlation between these data and results that have been obtained from miniplant-scale work.

RI 8477. Silver Recovery From Aircraft Scrap, by D. Harry Chambers and B. W. Dunning, Jr. 1980. 23 pp. 9 figs. The Bureau of Mines, through a memorandum of agreement with the Department of Defense, conducted research to recover silver from aircraft scrap. Silver was recovered by an electrolytic method from stainless steel honeycomb sections separated from the aircraft. These sections had been constructed by sandwiching a stainless steel honeycomb core between stainless steel sheets and then brazing the assembly with a silver alloy. Over 300 pounds of silver was used in the B-58 bomber, concentrated in certain honeycomb sections of the aircraft. Following shredding of the aircraft parts, an average of 95 percent (ranging 67 to 100 percent) of the silver was recovered in a single electrorefining step. After the electrorefined product was magnetically cleaned, purity of the recovered silver was greater than 99.3 percent.

RI 8478. Controlled Burnout of Wasted Coal on Abandoned Coal Mine Lands, by Robert F. Chaiken. 1980. 23 pp. 8 figs. A novel approach to eliminating environmental and public safety hazards that are associated with fires in abandoned coal mines and waste banks involves the use of in situ combustion technology developed by the Federal Bureau of Mines to accelerate the burning of the wasted coals in place. This technology would be used under exhaust ventilation control conditions that would allow for total management of the hot gases produced. Combustion stoichiometries would be optimized to minimize unburnt combustibles and to maximize the heat content of the gas products, which will be exhausted at one or more fan locations. When necessary, scrubber systems would be employed to remove air pollutants, such as sulfur dioxide; heat utilization systems (process heat, steam,

and electricity) would also be employed to offset operational costs. Ultimately, complete burnout would solve the fire and acid water formation problems of the abandoned coal mine or waste bank. Pertinent technical data for burnout control are derived and discussed in terms of the important material and operational parameters. In general, it is believed feasible to operate a burnout system in an existing abandoned mine or waste bank fire at thermal power levels in the range of 10 to 100 Mw, and at exhaust gas temperatures of 1,000° C (1,830° F).

RI 8479. Computer Modeling of Fluid Flow During Production and Environmental Restoration Phases of In Situ Uranium Leaching, by Robert D. Schmidt. 1980. 70 pp. 16 figs. This Bureau of Mines report describes the development and application of a computer model for simulating the hydrological activity associated with in situ leaching. The model is intended to provide uranium resource developers with a description of the flow behavior of leachants and ground water during the development, production, and restoration phases of a leaching operation involving an arbitrary pattern of injection and recovery wells. Different aquifer environments are modeled, using a closed-form solution to the partial differential equation that describes three-dimensional changes in piezometric head as a result of pumping from leachant injection and recovery wells. The computer program can model a maximum of 50 arbitrarily located wells. Numerical techniques involving difference quotients and Taylor expansions about time points are used to derive time, velocity, areal sweep, and fluid volume parameters associated with leaching hydraulics. These parameters are output by the program in graphic and tabular formats. Other numeric methods insure that the program running time is minimized without significantly affecting the accuracy of results.

RI 8480. A Simple, Low-Cost Method for the Dissolution of Metal and Mineral Samples in Plastic Pressure Vessels, by R. F. Farrell, S. A. Matthes, and A. J. Mackie. 1980. 14 pp. 2 figs. A goal of the U.S. Department of the Interior, Bureau of Mines, is the advancement of minerals technology through the development of improved metals and minerals processing. In support of this goal, the Bureau of Mines has developed a general method for preparing solutions from a wide range of metal and mineral samples for chemical analysis. The development of the method from current knowledge of vessel material, pressure dissolution techniques, and the fluoride-boric acid reaction is given. The method uses 7 ml of a mixture of HCl-HNO_3-HF acids in a ratio of 3.5:2:1.5 sealed in plastic bottles that act as pressure vessels when heated in a boiling water bath. A final volume of 100 ml is obtained by the addition of 93 ml of a 1.5-pct H_3BO_3 solution to the bottles, which are reheated; precipitated fluorides as well as sample residue are dissolved by the fluoride-boric acid reaction. A copper slag and a steelmaking slag treated using this method were analyzed by atomic absorption, spectroscopy, yielding values for Si, Mg, Ca, Al, Fe, Mn, Na, As, Pb, Sb, and Zn very close to certified values with an average relative standard deviation of 2.13 pct. The low cost, reduction in preparation time, ease and safety of sample handling, conservation of reagents, and ability to dissolve volatile materials without loss make this method superior to traditional wet digestion techniques for many materials, and ideal for use with atomic absorption, and optical emission or X-ray emission spectroscopy.

RI 8481. Cladding of Metals to Iron by Vacuum Rolling, by R. Blickensderfer. 1980. 25 pp. 22 figs. Maintaining an adequate supply of minerals and metals to meet national economic and strategic needs is the overall goal of the Bureau of Mines, U.S. Department of the Interior. One method of achieving this goal is to conserve scarce metals by cladding a plentiful base metal, such as iron, with a scarcer metal. To investigate cladding, a vacuum-rolling mill capable of rolling bimetal specimens at temperatures to 1,300° C in a residual gas pressure of 2×10^{-5} torr was established. Metals that were successfully bonded to iron included stainless steels, chromium, nickel, nickel alloys, copper, and several refractory metals including molybdenum and titanium. The effects of the rolling temperature, reduction in thickness, rolling speed, and residual air pressure on bonding strength and bend ductibility of the bimetals were determined. Optimum rolling conditions produced bimetals with bond shear strength essentially equal to that of the iron base metal.

RI 8482. Selective Flocculation and Flotation of a Mesabi Range Hematitic-Goethitic Taconite, by H. D. Jacobs and A. F. Colombo. 1980. 11 pp. 3 figs. The Bureau of Mines undertook a research program to insure an adequate supply of iron raw materials for future iron and steelmaking needs. A sample was obtained of oxidized taconite from the western Mesabi Range in Minnesota, and the metallurgical response of the taconite to beneficiation by a process that included selective flocculation-desliming-cationic flotation was evaluated. The sample contained 35.3 pct iron and represented approximately 2 billion tons of crude material. Selective flocculation and flotation were evaluated in a pilot plant with a feed rate of 900 lb/hr. Concentrates averaging 61.7 pct iron and 5.1 pct silica were obtained, with an accompanying iron recovery of 67.2 pct. About 83 pct of the process water requirements were reclaimed from the slime and froth tailing and then recycled.

RI 8483. Surface Charge Measurements of Amphibole Cleavage Fragments and Fibers, by J. E. Schiller and S. L. Payne. 1980. 23 pp. 12 figs. The Bureau of Mines has investigated the surface charge of amphibole asbestos fibers and nonasbestiform cleavage fragments, as part of the Bureau's fundamental studies to provide new knowledge on the physical and chemical properties of the amphibole minerals. Microelectrophoresis was used to measure the electrophoretic mobilities, in water, of particles from six asbestiform amphiboles and seven nonasbestiform amphiboles over the pH range of 5 through 9. The particles generally ranged in size from 2 to 5 μm wide by 10 to 30 μm long. The isoelectric point was determined for four of the minerals, and values were found to be between pH 3.5 and pH 5. The minerals studied had zeta potentials that generally ranged from -25 to -50 mv in neutral solution. Attachment of colloidal positively charged AgI was also studied as a means of determining surface charge. Scanning electron microscopy of amphibole particles that had been in contact with aqueous AgI showed equal attachment of AgI to asbestos fibers and to cleavage fragments; the extent of AgI coating was the same for both. The electrophoretic mobilities of asbestos fibers were essentially the same as those of elongated cleavage fragments of the same aspect ratio (particle length divided by width). Blocky particles from both asbestiform and nonasbestiform specimens had lower mobilities.

RI 8484. Rapid, Low-Cost Analysis of a Copper Slag for 13 Elements by Flame Atomic Absorption Spectroscopy, by S. A. Matthes. 1980. 8 pp. 2 figs. This Bureau of Mines report describes analysis of a copper slag for 13 elements from a single sample solution by flame atomic absorption spectroscopy. Samples are dissolved with 7 ml of an HCl-HF-HNO_3 (3:1.5:2) mixture in heated plastic pressure vessels. A 1.5-pct boric acid solution is added to dissolve precipitated fluorides and to reduce matrix effects that interfere with atomic absorption analysis. Preparation time is less than 1 hour per batch of 10 samples. Total analysis time is less than 6 person-hours for 130 determinations with an average relative standard deviation of 1.83 pct for the 13 elements. Simple acid standards were used for all determinations. Values obtained by this method are in excellent agreement with values obtained by slower, more costly procedures.

RI 8485. Structure Response and Damage Produced by Airblast From Surface Mining, by David E. Siskind, Virgil J. Stachura, Mark S. Stagg, and John W. Kopp. 1980. 111 pp. 48 figs. The Bureau of Mines studied airblast from surface mining to assess its damage and annoyance potential, and to determine safe levels and appropriate measurement techniques. Research results obtained from direct measurements of airblast-produced structure responses, damage, and analysis of instrument characteristics were combined with studies of sonic booms and human response to transient overpressures. Safe levels of airblast were found to be 134 dBL (0.1 Hz), 133 dBL (2 Hz), 129 dBL (6 Hz), and 105 dBL C-slow. These four airblast levels and measurement methods are equivalent in terms of structure response, and any one could be used as a safe-level criterion. Of the four methods, only the 0.1-Hz high-pass linear method accurately measures the total airblast energy present; however, the other three were found to adequately quantify the structure response and also represent techniques that are readily available to industry. Where a single airblast measuring system must be used, the 2-Hz linear peak response is the best overall compromise. The human response and annoyance problem from airblast is probably caused primarily by wall rattling and the resulting secondary noises. Although these will not entirely be precluded by the recommended levels, they are low enough to preclude damage to residential structures and any possible human injury over the long term.

RI 8486. Electrochemical Determination of Gibbs Energies of Formation of MnS and $Fe_{0.9}S$, by Seth C. Schaefer. 1980. 17 pp. 6 figs. As part of the Bureau of Mines effort to provide thermodynamic data for advancement of mineral resources technology, the standard Gibbs energies of formation ($\Delta G°f$) of MnS (manganese sulfide) and $Fe_{0.9}S$ (pyrrhotite) were investigated with a high-temperature galvanic cell employing stabilized ZrO_2 (zirconia) as the electrolyte.

RI 8487. Effects of Additives on Methanation Activity of Raney Nickel Catalysts, by James H. Russell, Laurance L. Oden, and Jack L. Henry. 1980. 21 pp. 2 figs. The Bureau of Mines, U.S. Department of the Interior, in cooperation with the Department of Energy, has attempted to increase the activity of nickel catalysts for converting synthesis gas, derived from coal, to a substitute natural gas. This report describes the effects of low-level additions of B, Ca, Ce, Co, Mn, Mo, Pd, Re, Ti, Y, Zn, and Zr on the methanation activity of Raney nickel. The methanation rate at 320° C and the resistance to poisoning by 2 ppm H_2S were used to compare catalysts. The effects of the additions were small, and the experimental variances were large, necessitating the use of statistical methods to identify significant effects. Co, Ti, Y, and Zn improved the resistance to H_2S poisoning, but only Co improved the methanation rate. In some individual catalysts containing Ca, Mo, or Mn, both the methanation rate and resistance to H_2S poisoning were improved. The work upon which this report is based was done under a cooperative agreement between the Bureau of Mines, U.S. Department of the Interior, and the U.S. Department of Energy.

RI 8488. Partial Replacement of Coke in Cupola Operation, by V. R. Spironello and W. M. Mahan. 1980. 19 pp. 1 fig. The Bureau of Mines is involved in research directed toward the conservation of important raw materials and the utilization of solid waste. Two of the objectives are to conserve high-quality coking coals used for foundry coke and to utilize waste materials of marginal quality but of high calorific value. These objectives are consistent with Bureau goals. Pilot plant cupola trials were made to evaluate the adequacy of various alternative fuels, and to determine to what extent they could replace the foundry coke in cupola charges. Information was obtained on furnace performance, metal and slag chemistry, environmental questions, and the properties of castings. It was shown that anthracite or bituminous coals can partially replace charge coke up to the 40-pct level. Briquetted materials prepared from fuel fines, and waste products or byproducts of high calorific value, all tend to break down on heating in a cupola so that their use must be restricted to below 20 pct replacement. In cases where pitch-bonded coal fines or petroleum coke were used, carbon pickup by the iron was inadequate for gray iron specifications. Although emphasis during this work was placed on basic slag practice, some acid practice results are included.

RI 8489. Recycling Spent Chrome Refractories From Steelmaking Furnaces, by E. Martin and A. V. Petty, Jr. 1980. 12 pp. 3 figs. In Bureau of Mines research on recycling chrome refractory wastes, used refractories from argon-oxygen decarburization and electric steelmaking furnaces were beneficiated, concentrates were reformed into briquets, and modulus of rupture tests were conducted at 1,350° C. The test results indicated that the beneficiated minus 6-mesh material could be used for producing magnesia-chrome refractories. Research at the Tuscaloosa Research Center is carried out under a memorandum of understanding between the Bureau of Mines, U.S. Department of the Interior, and the University of Alabama.

RI 8490. Electronic Ore-Sorting Tests on Native Copper Ore, by Jon K. Ahlness and James C. Kirchner. 1980. 36 pp. 13 figs. The Bureau of Mines, in cooperation with the Institute of Mineral Research of Michigan Technological University, and the Upper Great Lakes Regional Commission, conducted an investigation of electronic sorting of native copper ore from Upper Michigan. This report is based on research by the Institute of Mineral Research under contract to the Bureau. The test program evaluated the use of belt and rotary sorters on various size and grade fractions of ore. Both plant-scale sorting and lab sorting tests were run. The plant sorting

objectives were to determine the sortability of different ores and the efficiency of the electronic ore sorters. High- and low-grade ores from both conglomerate and amygdaloid types were separated into four size fractions. The two larger sizes were sorted on belt sorters and the two smaller ones on rotary sorters. Copper recoveries ranged from 20.0 pct from a feed grade of 0.40 pct to 80.3 pct from a feed grade of 1.08 pct. Lab sorting tests of conglomerate ore were run to determine the efficiency of a belt sorter equipped with a second sensing coil located above the belt and to determine the sorting characteristics of larger ore size fractions than those used in the plant sorting. Copper recoveries from the combined feed sizes ranged from 47.0 pct from a feed grade of 0.13 pct to 96.8 pct from a feed grade of 4.87 pct. For all the ore types except one, it was found that the copper recovery increased with the feed size.

RI 8491. Constructing Ventilation Bulkheads With Shotcreted Wire Panel, by K. Robert Dorman and Jan G. Patricio. 1980. 24 pp. 19 figs. This Bureau of Mines report describes laboratory and field experimentation in building mine ventilation stoppings, air-door frames, and fan bulkheads with a civil construction technique. Shotcrete is applied to a free-standing, three-dimensional wire-truss panel, which is easily cut and rapidly erected. In mines where shotcrete equipment is available, this technique should be faster and cheaper than conventional block-and-mortar or monolithic concrete construction.

RI 8492. Uranium Ion Exchange From Low-Grade Acidic Solutions in a Fluidized System, by G. R. Palmer, I. L. Nichols, and D. C. Seidel. 1980. 20 pp. 13 figs. Using a fluidized, countercurrent multiple-compartment ion-exchange (MCIX) column previously developed by the Bureau of Mines, Bureau researchers have successfully extracted uranium from a simulated acidic in situ leach liquor that contained 150 ppm U_3O_8. This successful demonstration of the MCIX system is reported, and the effects of varying the operating conditions on the performance of the system are also examined. Operating the MCIX system with a flow rate of 15 gpm/ft^2 and an aqueous-to-resin flow ratio of 200:1, more than 90 percent of the uranium was extracted, and a resin containing approximately 28 grams U_3O_8 per liter was produced. The absorption column used to investigate the operating variables was approximately 18 feet long with a 2-inch ID and was divided into compartments that were 1 foot long.

RI 8493. Behavior of Arsenic in a Static Bed During Roasting of Copper Smelter Feed, by Arne Landsberg, J. E. Mauser, and J. L. Henry. 1980. 18 pp. 17 figs. Accessory metals, although valuable resources, present possible environmental concern in the smelting of base metals. The Bureau of Mines, U.S. Department of the Interior, has undertaken research to define the chemistry involving these metals. Arsenic in copper smelting is the first to be investigated. Roasting, the first step in many copper smelters, was chosen for initial investigation because of the potential for arsenic removal in this primary process. Simple, static-bed, vaporization experiments were devised to obtain the data in this study. Ancillary transpiration and mass spectrometry were also used to delineate conditions necessary for arsenic volatilization from a roaster feed. For nearly complete arsenic removal, a temperature of 650°-700° C, a reducing atmosphere including carbon monoxide, and a source of sulfur were found to be essential.

RI 8494. Inorganic Cement for Mine Roof-Bolt Grouting, by R. E. Simpson, J. E. Fraley, and D. J. Cox. 1980. 32 pp. 16 figs. Beginning in 1972, fully grouted resin bolts were used in underground mines. An estimated 20 million resin bolts will be installed in 1980 owing to their apparent support improvement in most roof-bolt applications. Inorganic cements were tested to replace the resin at a lower cost while retaining the advantages of a grouted bolt. Although other inorganic materials were considered, all but portland and gypsum cements were rejected for reasons of availability, performance, or cost. Portland and gypsum-type cements were tested by the Bureau of Mines to select a fast-hardening, low-cost material that would anchor a roof bolt adequately to meet safety standards. An alpha-gypsum cement, accelerated with potassium sulfate, was selected as the best material because it had adequate pull strength at a desired set time of less than 5 minutes and was readily available.

RI 8495. Cladding Metals by Continuous Strip Rolling in Vacuum, by Robert Blickensderfer. 1980. 11 pp. 9 figs. Equipment and procedure for the continuous roll bonding of metal strips are described. The reels, mill rolls, and furnace were located within a vacuum chamber capable of operation at a residual gas pressure of 1×10^{-4} to 1×10^{-5} torr. Several metals were successfully clad at rolling temperatures of 930° to 1,050° C in lengths up to 120 ft. The bimetals that were clad included stainless steel to carbon steel, molybdenum, and nickel to stainless steel and carbon steel, and titanium to carbon steel. Bend tests of bond integrity are described, and microstructures of the interfaces are presented. The amounts of brittle intermetallic phases formed at the interface are minimized by this cladding method.

RI 8496. A Breathing Metabolic Simulator for Testing Respiratory Protective Equipment, by Anthony W. Sparks, Richard L. Stein, and Jerry W. Stengel. 1980. 18 pp. 14 figs. The Bureau of Mines conducted tests designed to compare its breathing metabolic simulator (BMS) with other methods that are currently used to evaluate the performance of respiratory protective equipment. The BMS is a commercially developed device that uses a piston cylinder to stimulate breath movement. Using a propane furnace that consumes oxygen and forms CO_2, the BMS also simulates the respiratory metabolism of humans. The breathing and metabolic subsystems of the BMS are described in detail in this report. Results are compared from tests that used the BMS to evaluate respiratory equipment and from tests that used human subjects for the same purpose. The BMS was also tested against a pulsatile breathing machine (PBM) previously designed by the Bureau. Both machines were used to test respiratory equipment, and the test results are compared in this report. To illustrate typical applications of the BMS, the report briefly describes how the BMS was used to test two different types of closed-circuit respiratory apparatus, and the test results are presented. This research showed that BMS test results compared more closely to the results of tests that used human subjects than did results obtained using the PBM.

RI 8497. Preparation and Chlorination of Titanium Carbide From Domestic Titaniferous Ores, by G. W. Elger, W. L. Hunter, and J. E. Mauser. 1980. 20 pp. 10 figs. The Bureau of Mines conducted laboratory and larger scale studies on samples of domestic perovskite and ilmenite ore concentrates to devise a procedure for recovering TiC from these ores. From the concentrates, mixtures of titanium and calcium carbides were produced. The carbides were then ground and reacted with water. This reaction decomposed the CaC_2 to acetylene and hydrated lime and simultaneously liberated the TiC. Using a combination of elutriation and gravity-separation techniques to separate the hydrated lime, approximately 93 pct of the titanium was subsequently recovered as purified carbide containing 54 to 70 pct titanium with CaO content as low as 0.6 pct. This combination of techniques can be used to separate more than 90 pct of the CaO from the TiC. Therefore, this carbiding procedure is a viable method for treating titaniferous materials, including perovskite, that contain more than 20 pct CaO. Tests made in a static-bed reactor showed that for the reaction of TiC with elemental chlorine to produce titanium tetrachloride ($TiCl_4$), a temperature of at least 940° F is desirable to achieve a suitable extraction of titanium in a laboratory chlorination reactor. In fluidized-bed tests at 840° F, 98 pct of the titanium contained in TiC was extracted.

RI 8498. Dewatering of Industrial Clay Wastes, by Annie G. Smelley, Bernard J. Scheiner, and Jalna R. Zatko. 1980. 13 pp. 3 figs. As a part of research conducted in its mission to effect pollution abatement, the Bureau of Mines, U.S. Department of the Interior, is developing a dewatering technique that allows for disposal of clay wastes, for reuse of water now lost with clays, and for reclamation of mined land. The technique utilizes a high-molecular-weight nonionic polyethylene oxide polymer (PEO) that has the ability to flocculate and dewater materials containing clay wastes. In laboratory experiments, coal-clay waste, potash-clay brine slurry, phosphatic clay waste, uranium tailings, and talc tailings were successfully consolidated. Coal-clay waste was consolidated from 3.6 to 57 percent; potash-clay brine slurry was consolidated from 3.8 to 35 percent; phosphatic clay waste from 15.6 to 49 percent; uranium tailings from 15.4 to 67 percent; tailings from talc production from 9.7 to 53 percent; and an acidic TiO_2 slurry from 1.68 to 30 percent. 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 8499. Characterization of Pre-1957 Avionic Scrap for Resource Recovery, by B. W. Dunning, Jr., and F. Ambrose. 1980. 20 pp. 1 fig. This paper describes studies conducted by the Bureau of Mines to achieve its goal of developing methods for increased recovery and utilization of valuable constituents in a wide variety of domestic and industrial wastes. In this particular study, 36 units of obsolete electronic equipment from military aircraft were disassembled into their modular components by hand to determine materials distribution. Further modular disassembly into individual parts was used to identify metal composition. After identifying the metals in some of the more difficult to dismantle modules, similar modules were grouped together, shredded, mechanically separated, and using metal composition data from hand separation, classified along with the hand-separated materials. Although this equipment is normally classified as low-value iron-bearing aluminum, data were obtained that indicated the potential for moderately higher value classification. The electronic units were classified as to precious metals, copper, iron, and aluminum contents, and scrap values were estimated.

RI 8501. Characterization of Residues From Selected Coal Conversion Processes, by E. Martin and G. V. Sullivan. 1980. 13 pp. 3 figs. As part of the Bureau of Mines subactivity in secondary resource recovery and to expand the Nation's mineral base, the Tuscaloosa Research Center made characterization and preliminary beneficiation studies of the waste residues from various coal-conversion processes: from pilot plant tests of the Synthane process for coal gasification, the Synthoil process for coal liquefaction, and the solvent-refined coal (SRC) process for sulfur removal from coal. Those coal conversion processes selected for this study were based on the availability of pilot plant samples. Physical, chemical, and mineralogical examinations of the wastes made to determine the mineral content prior to physical beneficiation tests indicated that in addition to significant quantities of carbon, some trace elements offer potential for concentration.

RI 8506. Measurement of Blast-Induced Ground Vibrations and Seismograph Calibration, by Mark S. Stagg and Alvin J. Engler. 1980. 62 pp. 44 figs. Blast-induced ground vibrations from surface coal mine, quarry, and construction blasting were measured and analyzed for frequency content and duration characteristics. Eighteen commercially available ground vibration measurement systems were evaluated in the field and laboratory for linearity, accuracy, and crosstalk. Buried, surface, and sandbagged transducer placement methods were compared, along with peak and vector-sum measurements. The recommended minimum frequency ranges for ground vibration instrumentation are 2 to 150 Hz for coal mine and quarry blasting, and 5 to 200 Hz for construction and excavation blasting. When higher or lower frequency vibrations are possible, as in construction blasting or for a quarry shot close to a residence, care should be taken to insure proper choices of instrumentation and vibration criteria. Several instruments operating in these ranges are available, and all but one of the seismographs tested fell within ±3-dB accuracy limits (+41 pct, -29 pct). Waveform recordings of all three ground vibration components are recommended as the peak amplitude and frequency may vary among the three. Peak or vector-sum readings are adequate if only amplitude levels are desired. The soil density matched box should be anchored or buried, particularly for high-frequency, high-amplitude construction blasting.

RI 8507. Structure Response and Damage Produced by Ground Vibration From Surface Mine Blasting, by D. E. Siskind, M. S. Stagg, J. W. Kopp, and C. H. Dowding. 1980. 74 pp. 68 figs. The Bureau of Mines studied blast-produced ground vibration from surface mining to assess its damage and annoyance potential, and to determine safe levels and appropriate measurement techniques. Direct measurements were made of ground-vibration-produced structure responses and damage in 76 homes for 219 production blasts. These results were combined with damage data from nine other blasting studies, including the three analyzed previously for Bureau of

Mines Bulletin 656. Safe levels of ground vibration from blasting range from 0.5 to 2.0 in/sec peak particle velocity for residential-type structures. The damage threshold values are functions of the frequencies of the vibration transmitted into the residences and the types of construction. Particularly serious are the low-frequency vibrations that exist in soft foundation materials and/or result from long blast-to-residence distances. These vibrations produce not only structure resonances (4 to 12 Hz for whole structures and 10 to 25 Hz for midwalls) but also excessive levels of displacement and strain. Threshold damage was defined as the occurrence of cosmetic damage; that is, the most superficial interior cracking of the type that develops in all homes independent of blasting. Homes with plastered interior walls are more susceptible to blast-produced cracking than modern gypsum wallboard; the latter are adequately protected by a minimum particle velocity of approximately 0.75 in/sec for frequencies below 40 Hz. Structure response amplification factors were measured; typical values were 1.5 for structures as a whole (cracking) and 4 for midwalls, at their respective resonance frequencies. For blast vibrations above 40 Hz, all amplification factors for frame residental structures were less than unity. The human response problem from ground vibration is aggravated by wall rattling, secondary noises, and the presence of airblast. Approximately 5 to 10 pct of the neighbors will judge peak particle velocity levels of 0.5 to 0.75 in/sec as "less than acceptable" (that is, unacceptable) based on direct reactions to the vibration. Even lower levels cause psychological response problems, and thus social, economic, and public relations factors become critical for continued blasting.

COOPERATIVE PUBLICATIONS

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 1–80. Geology and Mineral Resources of the North Absaroka Wilderness and Vicinity, Park County, Wyoming, by Willis H. Nelson, Harold J. Prostka, and Frank E. Williams. With sections on mineralization of the Sunlight mining region and geology and mineralization of the Cooke City mining district, by James E. Elliott, and a section on aeromagnetic survey, by Donald L. Peterson. 1980. 101 pp. 22 figs. 2 pl. Geol. Survey Bull. 1447. GPO Stock No. 024–001–03271–6. $4.50.

GS 2–80. Mineral Resources of the Indian Peaks Study Area, Boulder and Grand Counties, Colorado, by Robert C. Pearson and U.S. Bureau of Mines. With a section on interpretation of aeromagnetic data, by Gordon Johnson. 1980. 109 pp. 12 fig. 2 pl. Geol. Survey Bull. 1463. GPO Stock No. 024–001–03303–8. $5.50.

GS 3–80. Mineral Resources of the Sturgeon River Wilderness Study Area, Houghton and Baraga Counties, Michigan, by W. F. Cannon, Elizabeth R. King, James J. Hill, and Peter C. Mory. 1980. 49 pp. 18 figs. Geol. Survey Bull. 1465. GPO Stock No. 024–001–03259–7. $3.25.

GS 4–80. Mineral Resources of the Dolly Sods Wilderness Area, Grant, Randolph, and Tucker Counties, West Virginia, by Kenneth J. Englund, Ralph C. Warlow, James J. Hill, Peter C. Mory, Bradford B. Williams, and Maynard L. Dunn, Jr. With sections on peat resources, by Cornelia C. Cameron, geochemical survey, by Frank G. Lesure, and oil and gas potential, by William J. Perry, Jr. 1980. 52 pp. 19 figs. 3 pl. Geol. Survey Bull. 1483–A. GPO Stock No. 024–001–03340–2. $3.75.

INFORMATION CIRCULARS

IC 8811. Methodology for Evaluating Integral Gaussian Profiles, by Arthur B. Campbell III. 1980. 18 pp. 2 figs. This Bureau of Mines report describes a method that utilizes a computer program to evaluate integral Gaussian profiles of atomic concentration versus depth in a solid. The specific use illustrated involves profiling ion-implanted metals using proton-induced X-ray emission (PIXE) analysis and ion sputtering (IS) for sectioning.

IC 8812. Bureau of Mines Health and Safety Research. A Status Report Covering Nov. 1, 1978–May 31, 1979, by Staff, Bureau of Mines. 1980. 41 pp. This status report contains 39 individual reports on health and safety research projects now being conducted or recently completed by the Bureau of Mines. The reports on health research cover industrial hygiene, respirable dust, ventilation, noise control, and radiation hazards. The safety research reports cover industrial hazards, ground control, fire and explosion prevention, and methane control. Each report includes background information, a discussion of research progress, and an assessment of each project's current status.

IC 8813. Iron Oxide Pigments (in Two Parts) 2. Natural Iron Oxide Pigments—Location, Production, and Geological Description, by Janice L. W. Jolly and Cynthia T. Collins. 1980. 79 pp. 15 figs. This Bureau of Mines publication reviews the location, principal producers, and geologic occurrence of natural iron oxide pigment deposits. The most famous deposits are found in Cyprus, Iran, Spain, France, Italy, and the Federal Republic of Germany; significant deposits are also exploited in India, the Republic of South Africa, and the United States. Some other countries where iron oxide pigment deposits are, or have been, exploited include Argentina, Australia, Brazil, Burma, Canada, Chile, Egypt, Israel, Jordan, Kenya, Mexico, Morocco, Pakistan, Paraguay, Sweden, the United Kingdom, and Venezuela. Most iron oxide pigment deposits were derived by decomposition of rocks and minerals, resulting in the secondary redistribution and concentration of liberated iron into favorable sites of accumulation. Gossans, laterites, bog iron ores, karst sediments, river channel sediments, and contact metamorphic limestones are favorable sites for iron oxide pigment deposits. Large-scale sedimentary iron deposits such as the minette, Clinton, and black band ores, and Precambrian iron formations are also important pigment sources. Iron oxide pigments are both mined as a primary product and produced as a byproduct of mining other ores, such as iron ore, barite, or sulfides. Maps, tables of production and trade, and lists of producers are included where possible. GPO Stock No. 024–004–01960–3. $3.75.

IC 8814. Valuation of Potash Occurrences Within the Nuclear Waste Isolation Pilot Plant Site in Southeastern New Mexico, by Robert C. Weisner, Jim F. Lemons, Jr., and Luis V. Coppa. 1980. 94 pp. 32 figs. Current production costs and market conditions in the potash industry of the Carlsbad area were studied to determine the potential values of the potash mineral resource that would be lost or foregone if the Waste Isolation Pilot Plant (WIPP) facility is constructed on the proposed site in that area. The purpose of the WIPP project is to investigate the possibility of developing a nuclear waste disposal plant in the salt formations at the site. Mining and processing under the most favorable recovery systems were considered. Value determinations were based upon estimated operating and capital costs of current mine-mill operations in the Carlsbad area. This study was made for the Energy Research and Development Administration (ERDA) by members of the Federal Bureau of Mines Minerals Availability System staff. GPO Stock No. 024–004–01959–0. $4.75.

IC 8815. MILS: The Mineral Industry Location System of the Federal Bureau of Mines, by Andrew W. Berg and Fred V. Carillo. 1980. 24 pp. 16 figs. The Bureau of Mines Mineral Industry Location System (MILS) is part of the computerized Minerals Availability System (MAS), a comprehensive data base of known mineral deposits. MILS, the location subsystem of MAS, has become widely used by the minerals industry and organizations with land-use planning and land management responsibilities. Information on more than 135,000 mineral locations and processing plants in the United States is contained in the data base. This information includes the name, location, mineral commodity, type of operation, bibliography, and cross-references for each property or prospect. Computer-drawn map overlays at various scales showing clustered MILS locations and computer printouts keyed to those overlays are available for inspection and reproduction at the Bureau's Field Operations Centers at Juneau, Alaska, Denver, Colo., Pittsburgh, Pa., and Spokane, Wash. GPO Stock No. 024–004–01962–0. $2.25.

IC 8816. Minerals Health and Safety Contract Research, Development, and Demonstration in Fiscal Year 1980, by Staff, Division of Minerals Health and Safety Technology. 1980. 50 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 1980 (October 1, 1979-September 30, 1980) under its Minerals Health and Safety Research 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 8817. Minerals Health and Safety In-House Research, Development, and Demonstration in Fiscal Year 1980, by Staff, Division of Minerals Health and Safety Technology. 1980. 34 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 1980 (October 1, 1979-September 30, 1980) under its Minerals Health and Safety Research 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 8818. The Physical Chemistry of Mineral-Reagent Interactions of Sulfide Flotation. Proceedings of Symposium Held at College Park, Md., April 6–7, 1978, compiled by Paul E. Richardson, Garrett R. Hyde, and Morris S. Ojalvo. 1980. 171 pp. This symposium was sponsored by the Bureau of Mines, U.S. Department of the Interior, in order to critically examine the state-of-the-art of sulfide flotation chemistry and to define current and emerging problems that should be emphasized in future fundamental research. The topics covered through invited papers include both reviews and recent research results in the areas of thermodynamics of reagent-mineral interactions; collector adsorption processes; the effects of solid-state point defects on flotation; activation and deactivation phenomena; the electrochemical role of oxygen in sulfide flotation; environmental problems in flotation; and selective flocculation of fines. Papers giving perspectives on flotation research in relationship to our national mineral requirements and the relationships between industrial flotation research and academics are also presented. An edited summary of the symposium follows the papers.

IC 8819. Analytical Chemistry of the Citrate Process for Flue Gas Desulfurization, by W. N. Marchant, S. L. May, W. W. Simpson, J. K. Winter, and H. R. Beard. 1980. 20 pp. 10 figs. The citrate process for flue gas desulfurization (FGD) is a product of continuing research by the U.S. Bureau of Mines to meet the goal of minimizing the objectionable effects of minerals industry operations upon the environment. The reduction of SO_2 in solution by H_2S to produce elemental sulfur by the citrate process is extremely complex and results in solutions that contain at least nine different sulfur species. Process solution analysis is essential to a clear understanding of process chemistry and its safe, efficient operation. The various chemical species, the approximate ranges of their concentrations in citrate process solutions, and the analytical methods evolved to determine them are hydrogen sulfide ($\sim 0M$ to $0.06M$) by specific ion electrode, polysulfides (unknown) by ultraviolet (UV) spectrophotometry, elemental sulfur ($\sim 0M$ to $\sim 0.001M$ dissolved, $\sim 0M$ to $\sim 0.1M$ suspended) by UV spectrophotometry, thiosulfate ($\sim 0M$ *to* $\sim 0.25M$) by iodometry or high performance liquid chromatograph (HPLC), polythionates ($\sim 0M$ *to* $\sim 0.01M$) by thin layer chromatography (TLC), dithionite (searched for but not detected in process solutions) by polarography or TLC, bisulfite ($\sim 0M$ to $0.2M$) by iodometry, sulfate ($\sim 0M$ to $1M$) by a Bureau-developed gravimetric procedure, citric acid ($\sim 0M$ to $0.5M$) by titration or visible colorimetry, glycolic acid ($\sim 0M$ to $1M$) by HPLC, sodium ($\sim 1.5M$) by flame photometry, and chloride by argentometric titration.

IC 8820. Supply Analysis Model (SAM): A Minerals Availability System Methodology, by Robert L. Davidoff. 1980. 45 pp. 10 figs. Growing domestic and global demands for mineral resources have established an imperative need for developing comprehensive, versatile mineral supply analysis evaluation tools. The Minerals Availability System (MAS) of the Bureau of Mines is meeting this need with its computerized Supply Analysis Model (SAM). This paper describes the SAM system and the quantitative methods used by the MAS for mineral supply analyses. The MAS evaluating process consists of deposit identification, tonnage and grade determinations, engineering and cost evaluations, financial analyses, and supply curve generation. MAS has developed this computerized system primarily to facilitate the maintenance of data information for the constructing of commodity supply curves. The SAM system presently has the analytical capabilities of simultaneously (1) evaluating many mineral deposits, (2) updating mineral supply information to reflect inflationary changes in costs and prices, and (3) conducting sensitivity analysis to determine impacts on mineral supply under various conditions. Many potential users in both government and industry will find the SAM system a valuable tool for policy analysis, forecasting, and planning. The SAM system has been constructed so that any types of information that are similar to the data elements in the MAS data base may be used to perform supply studies. The storage space needed for the SAM system's programs, files, and output data is approximately 14 million characters. GPO Stock No. 024–004–01963–8. $3.25.

IC 8821. Availability of Critical Scrap Metals Containing Chromium in the United States. Superalloys and Cast Heat- and Corrosion-Resistant Alloys, by LeRoy R. Curwick, Walter A. Petersen, and Harry V. Makar. 1980. 51 pp. 11 figs. This Bureau of Mines report presents the results of a study conducted to assess the domestic availability of chromium from superalloy and cast heat- and corrosion-resistant alloy scrap material. Six alloy classes included in this survey were investment cast, hardfacing, and wrought nickel- and cobalt-base alloys, wrought nickel-iron-base alloys, and heat- and corrosion-resistant alloy castings. Data were collected for 1976 on metallic scrap generation, use patterns, and production practices for these alloy producing and using industries. A model was developed that allowed an assessment of the materials flow circuits within the industries that produce these alloys. The types, amounts, sources, secondary products, and ultimate destinations of chromium-containing metallic scrap for the six alloy classes were determined. Regarding the overall recycling efficiency of these alloy producing and using industries, of the 580.9 million pounds of scrap generated from these six alloy classes in 1976, about 72 percent (416.8 million pounds) was remelted by the same alloy-producing industries, about 18 percent (104.9 million pounds) was downgraded into stainless and low-alloy steels, about 3 percent (19.7 million pounds) was exported, and about 7 percent (39.5 mllion pounds) was lost through landfill or other disposal or service wastage. The lost material is primarily contaminated oxides for which recovery is currently uneconomic. However, the 124.6 million pounds of scrap material downgraded or exported in 1976 contained potentially recoverable critical strategic elements. The amount of scrap material lost to the six alloy-producing industries in this manner contained 22.1 million pounds of chromium, 53.4 million pounds of nickel, 5.9 million pounds of cobalt, 35.9 million pounds of iron, and 7.3 million pounds of other alloying elements. GPO Stock No. 024–004–01985–9. $3.75.

IC 8822. Availability of Critical Scrap Metals Containing Chromium in the United States. Wrought Stainless Steels and Heat-Resisting Alloys, by Charles L. Kusik, Harry V. Makar, and Michel R. Mounier. 1980. 51 pp. 6 figs. As part of an effort to establish the extent of the domestic chromium supply that could be exploited in case of adverse changes in international chromium production and trading patterns, a two-part study was conducted for the Bureau of Mines, to assess the domestic availability of critical metals in scrap containing significant amounts of chromium. This report describes the part of the study that deals with wrought stainless steels and heat-resisting alloys. Data were collected on types of scrap, sources, quantities, and ultimate disposition, leading to the conclusion that in 1977 about 62,000 tons of contained chromium was unrecycled. Unrecovered obsolete stainless steel scrap accounts for most of these uncollected chromium values. Error margins in the amount of uncollected scrap are estimated to be 10 to 20 percent. GPO Stock No. 024–002–01986–7. $3.75.

IC 8823. Surface Coal Mining Reclamation Equipment and Techniques. Proceedings: Bureau of Mines Technology Transfer Seminars, Evansville, Ind., June 3, 1980, and Denver, Colo., June 5, 1980, compiled by Staff — U.S. Bureau of Mines. 1980. 80 pp. 36 figs. These proceedings consist of papers presented at two Bureau of Mines Technology Transfer Seminars in early 1980 for the purpose of disseminating recent advances in mining technology related to surface coal mining reclamation.

IC 8824. Mineral Depletion Allowances and U.S. Import Dependence, by Phillip N. Yasnowsky and Annette P. Graham. 1980. 13 pp. This Bureau of Mines report examines the percentage depletion allowance rate structure in relation to several criteria that are indicative of U.S. mineral import dependence. These criteria are the minerals considered as strategic and critical for stockpiling purposes, the ratio of reserves to forecast cumulative demand (1976-2000) for selected minerals, and the U.S. net import reliance as a percentage of apparent consumption (1978), also for selected minerals. In general, it was found that there does exist a direct, although not perfect, relationship between the percentage depletion allowance rates and the degree of import dependence as indicated by these three criteria. The higher percentage rates tend to be associated with those minerals for which the United States is, or will likely be, heavily dependent on foreign sources. In addition, a basic discussion of the mineral depletion allowance is provided, including numerical examples illustrating the computation of the allowance under several assumptions. Also, the percentage depletion allowance rates for individual minerals are tabulated. GPO Stock No. 024–004–01987–5. $1.50.

IC 8825. Bureau of Mines Statistical Projection Methodology of U.S. Mineral Consumption by End Use: Aluminum as an Example by William Y. Mo and Barry W. Klein. 1980. 109 pp. 89 figs. This Information Circular provides a detailed background documentation of how the Bureau of Mines projects U.S. mineral demand to the year 2000. These statistical projections serve as a quantitative basis for contingency forecasting of the low, high, and probable U.S. demand for nonfuel minerals by end-use categories and are published in the Bureau of Mines Mineral Commodity Profiles and Mineral Facts and Problems series. Aluminum is used as an example in this study. GPO Stock No. 024–004–01995–6. $4.50.

IC 8826. Materials Recycling. An Overview of the Sixth Mineral Waste Utilization Symposium, compiled by S. A. Bortz and K. B. Higbie. 1980. 157 pp. 28 figs. This Bureau of Mines report reviews the information presented at the Sixth Mineral Waste Utilization Symposium cosponsored by the Bureau of Mines, U.S. Department of the Interior, and the ITT Research Institute. Environmental scientists and engineers from nine countries participated in the symposium, which was held May 2-3, 1978, at the Chicago campus of ITT Research Institute. The 56 papers presented on the reclamation and recycling of mining and mineral wastes, municipal solid waste, industrial wastes, and scrap metal are summarized herein.

IC 8827. Minerals Environmental In-House and Contract Research and Development in Fiscal Year 1980, by Staff, Division of Minerals Environmental Technology. 1980. 41 pp. This publication summarizes the in-house and contract research and development projects programed for fiscal year 1980 by the Bureau of Mines under its Minerals Environmental Research 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. Through the years, efforts of various Bureau programs have yielded valuable information on the origin and control of many of these problems. With the reorganization of the Bureau of Mines in 1979, the Minerals Environmental Technology program was structured to consolidate these efforts into a single program that will systematically investigate all aspects of mining- and processing-related environmental pollution and damage—from initial discovery of the mineral resource to ultimate return of the land to productive use. In fiscal year 1980, the Bureau received an appropriation of about $21 million to conduct research and development work on these problems.

IC 8828. Surface Mine Truck Safety. Proceedings: Bureau of Mines Technology Transfer Seminars, Minneapolis, Minn., June 25, 1980, Birmingham, Ala., July 9, 1980, and Tucson, Ariz., July 24, 1980, compiled by Staff —Bureau of Mines. 1980. 61 pp. 41 figs. These proceedings consist of an introduction and four descriptive papers. The first paper is an update on fire protection for large haulage vehicles, the second paper is concerned with improved visibility systems for large haulage vehicles, the third paper is on improved ladders for large haulage vehicles, and the fourth paper is concerned with large haulage vehicle operator training systems.

IC 8829. Review of Horizontal Drilling Technology for Methane Drainage From U.S. Coalbeds, by Gerald L. Finfinger and Joseph Cervik. 1980. 20 pp. 13 figs. This Bureau of Mines publication reviews underground methane drainage programs being conducted in various coalbeds. Equipment used in drainage programs such as drills, underground pipelines, and methane monitoring systems is described.

IC 8830. A Statistical Analysis of Coal Mine Fire Incidents in the United States From 1950 to 1977, by L. Bruce McDonald and William H. Pomroy. 1980. 42 pp. 3 figs. This Federal Bureau of Mines publi-

cation is a statistical analysis of all surface and underground coal mine fires reported in the United States from 1950 to 1977. Accounts of selected nonreportable fires and opinion data gathered via interviews with mine safety directors were separately analyzed. Both reported and nonreportable fires were analyzed by time trends, State, ignition source, burning substance, location in mine, equipment, detection, duration, injuries, fatalities, and successful extinguishing agents. It was found that the majority of all mine fires were electrical in origin. The equipment most frequently involved in underground fires was conveyor belts, and in surface fires, it was crushers and/or breakers. Underground fires occurred most often near the working face. Water and hand-portable extinguishers were the most common method of extinguishment.

IC 8831. Helium Resources of the United States, 1979, by B. J. Moore. 1980. 27 pp. 7 figs. The Bureau of Mines has estimated helium resources of the United States at 727 billion cubic feet as of January 1, 1979. These resources are divided into four categories in decreasing degrees of assurance of their existence: (1) Helium in storage and in measured natural gas reserves, 185 billion cubic feet; (2) helium in indicated natural gas resources, 150 billion cubic feet; (3) helium in hypothetical natural gas resources, 186 billion cubic feet; and (4) helium in speculative natural gas resources that makes up the remaining 206 billion cubic feet. The identified helium reserves, which are made up of that in measured and indicated natural gas categories, are further divided into depleting, nondepleting, and stored classifications. The depleting resources are those that are associated with natural gasfields that are, or will be, produced for the natural gas they contain. All of the helium in undiscovered natural gas resources are included in this classification. These depleting resources comprise 600 billion cubic feet of the total resource base. The nondepleting helium resources are estimated to total 88 billion cubic feet. There is 39 billion cubic feet of helium in storage in Cliffside gasfield near Amarillo, Tex. GPO Stock No. 024–004–02001–6. $2.

IC 8832. Automatic Fire Protection Systems for Surface Mining Equipment, by William H. Pomroy and Kenneth L. Bickel. 1980. 38 pp. 32 figs. Fire on surface mining equipment is a serious hazard to life and property. The Bureau of Mines, through a program of contract and in-house research, has developed and in-mine demonstrated reasonably priced, reliable automatic fire protection systems to deal with this problem. This report reviews the development and subsequent testing of systems for haulage trucks, front-end loaders, coal augers, dozers, drills, and shovels. A variety of fire sensors, extinguishing agents, and control systems are discussed in the context of mine equipment designs and operating environments.

IC 8833. Analyses of Natural Gases, 1979, by B. J. Moore. 1980. 100 pp. 1 fig. This publication contains analyses and related source data for 269 natural gas samples from wells and pipelines in 18 States. All of the samples were obtained and analyzed during calendar year 1979 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. 024–004–02013–0. $4.50.

IC 8834. The Impact of U.S. Railroad Abandonment on Domestic Mineral Industries, by Ronald F. Balazik. 1980. 18 pp. 1 fig. This Bureau of Mines study is intended to identify and evaluate potential effects of impending large-scale U.S. rail line closings (abandonment) on domestic nonfuel mineral industries. This is the first nationwide study of rail abandonment impacts focused on nonfuel minerals. The analysis presented is based principally on a survey of 200 rail freight records and on statistical tests that correlated 2,000 points in the Bureau's Mineral Industry Location System (MILS) with 700 prospective abandonments throughout the United States. The conclusions derived from the analysis can be useful in evaluating proposed national rail abandonment policy and legislation regarding nonfuel mineral shipping. Among these conclusions are the following: (1) Certain mineral materials (especially fertilizers) are likely to account for a large percentage of the rail traffic affected by abandonment in the next few years, but the total tonnage involved will be small; (2) abandonment will adversely affect some mineral shippers, particularly local short haulers; and (3) abandonment could significantly reduce the opportunity to develop new resources or reopen defunct mining facilities. Despite these problems, however, the data examined in this study do not indicate that current abandonment trends will cause widespread disruption of domestic nonfuel mineral shipping. GPO Stock No. 024–004–02016–4. $1.75.

IC 8835. Guide to Substation Grounding and Bonding for Mine Power Systems, by Wils L. Cooley and Roger L. King. 1980. 27 pp. 16 figs. Although electric utility companies have been active in grounding and bonding within substations, the mining engineer or mine electrical engineer is not involved to the extent that he can be fully up-to-date on the most effective practices for substation construction. The coal mine power system is grounded in a fundamentally different way from most other industrial power systems and is subject to considerable Federal and State regulations. At this time, there is little information that is directly applicable to the mine situation, especially if the substation must be built in an area of limited size or in low-conductivity earth. The objective of this guide is to provide specific engineering information to the mining industry. Using as little theory as possible, it was written to be general enough to cover most substations, but specific enough to provide direct help with each substation. It will attempt to recommend practice that is in agreement with present Federal rules and regulations.

IC 8836. The U.S. Copper Mining Industry. A Perspective on Financial Health, by T. T. Tomimatsu. 1980. 20 pp. 3 figs. This Bureau of Mines paper investigates, explores, and analyzes the corporate structure dynamics and financial ratios to evaluate the economic health of the U.S. copper producers. It highlights the corporate policy options and measures of corporate profitability and suggests that a competitive domestic copper industry will exist in the future. The study highlights the activities of 14 selected major copper-producing companies, including their subsidiaries or affiliates, that were responsible for more than 95 percent of the total U.S. production in each of the years since 1969. The selected firms are not all primarily in the

business of producing copper. Several of the large producers are classified by the financial institutions as integrated oil and gas enterprises. GPO Stock No. 024–004–02002–4. $1.75.

SPECIAL PUBLICATIONS

SP 1–80. List of Bureau of Mines Publications and Articles, January 1 to December 31, 1978. With Subject and Author Index, compiled by Shelby Z. Palya. 1980. 125 pp. This compilation supplements the 5-year list of Bureau publications issued from January 1, 1970, to December 31, 1974, the annual list issued from January 1 to December 31, 1975, the annual list issued from January 1 to December 31, 1976, and the annual list issued from January 1 to December 31, 1977. The list 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. An outstanding feature of this Special Publication is an exhaustive subject and author index. GPO Stock No. 024–004–01958–1. $4.25.

SP 2–80. Bureau of Mines Research 79. A Summary of Significant Results in Mining, Metallurgy, and Mineral Economics, by Staff, Bureau of Mines. 1980. 112 pp. 50 figs. Minerals are vital to the economic well-being of our society. We depend on automobiles, metal containers, glass, gypsum wallboard, copper wire, steel and concrete buildings, and countless other goods, all of them requiring the processing of minerals. The demand for the mineral raw materials necessary to create these products is rising rapidly, creating unprecedented worldwide competition. It is now more important than ever to recover minerals from lower grade ores, recycle mineral materials, and substitute abundant materials for scarce ones. Yet, the economic aspects of our mineral resources are not the only factors to be considered. We are more aware than ever of the environmental impact of mineral production, and more determined than ever to minimize its adverse effects. The health and safety of workers in the mineral industries continue to be of prime importance. We also recognize that social, political, or economic situations in distant countries can affect our supplies of essential mineral commodities. During the past year, the Bureau of Mines underwent intensive examination to determine how it could best meet these challenges. It was recognized that such complex issues require rapid, comprehensive analysis of mineral-related issues and policies, along with research and development programs that are responsive and efficiently conducted. The internal organization of the Bureau was restructured to combine this type of analysis with an ongoing program planning effort more responsive to today's rapid change. Research 79, the ninth in this annual series, reflects the Bureau's new emphasis and renewed commitment. Research 79 highlights significant research conducted during the past year under contract or at the Bureau's research facilities throughout the United States. Readers who desire more information about the projects and studies reviewed are encouraged to contact the researchers whose names appear with each summary. A directory and a listing of publications authored by Bureau personnel in the past 3 years appear at the end of the publication. GPO Stock No. 024–004–01964–6. $4.25.

SP 3–80. Mining Research Review, by Staff, Bureau of Mines. February 1980. 93 pp. 72 figs. The Bureau of Mines mining research activities are mission oriented and are directed towards the conservation of our Nation's mineral resources, the protection of the miner from health and safety hazards, and the control of social and economic costs to help assure a viable mining industry in the United States. Research efforts are conducted on mining health and safety, production, and environmental control. The largest of these areas, health and safety, has been the agency's major mining research responsibility since the Bureau was established in 1910. For administrative purposes this research is subdivided into (1) coal health, (2) coal safety, and (3) metal and nonmetal health and safety. The annual Mining Research Review provides an overview of current mining research project activities.

OPEN FILE REPORTS

OFR 1–80. Underground Disposal of Retorted Oil Shale for the Paraho Retorting Process, by H. W. Earnest, R. A. Heisler, H. L. Hoe, and V. Rajaram. May 1978. 379 pp. 51 figs. This report covers the results of a two-phase study to determine the feasibility of underground disposal of retorted oil shale. Two mining methods, chamber and pillar mining and sublevel stoping, were specified for backfilling. Phase I covered the evaluation of hydraulic, mechanical, and pneumatic transport and stowing systems, individually and in various combinations, and the selection of the most feasible methods. Conveyor transport and stowing and a combination conveyor transport and stowing with pneumatic topfilling were selected for detailed study. Phase II activities included detailed engineering analysis and design of the selected systems, an engineering economic analysis, and a cost comparison with total surface disposal of retorted oil shale. An extensive literature search was conducted and the bibliography is included. Research done under Contract No. J0265052 by Cleveland-Cliffs Iron Co. Available for reference at Bureau of Mines facilities in Denver, Colo., Twin Cities, Minn., Bruceton and Pittsburgh, Pa., 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 80–128739, paper copy price code A17.

OFR 2–80. Development of New Design Concepts for Construction of Valley Fills, by LeRoy D. Loy, Jr., Charles E. Ettinger, Michael R. Frakes, and Donald J. Kremer. Oct. 16, 1978. 160 pp. 37 figs. The disposal of excess overburden from surface mining can be accomplished by use of a reclamation technique entitled head-of-hollow or valley fill. This report attempts to assess current valley fill regulations and practices, identifies inherent benefits and deficiencies, and develops concepts to enhance fill technology. Research done under Contract J0177063 by Skelly and Loy. Available for reference at Bureau of Mines facilities in Denver, Colo., Twin Cities, Minn., Pittsburgh, Pa., 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 80–126055; paper copy price code A08.

OFR 3(1)–80. The Development of a Cross-Pit Overburden Handling System. Volume I—Preliminary Design, by J. Ritchey, F. H. Hagenbuch, and J. Mantel. October 1976. 68 pp. 18 figs. This report describes the engineering feasibility and economic advantages of using a mobile bridge-type, cross-pit belt conveyor system in conjunction with a large dragline to excavate and transport spoils in a typical western surface coal mine. The studies show that such a system could be built to survive operational and climatic mining conditions and that its implementation would offer a reduction in both acquisition and operating costs versus conventional mining units of comparable capacity. Reclamation costs can also be significantly reduced and the total reclamation process accelerated, making the cross-pit conveyor system attractive to mine owners and environmentalists alike. Research done under Contract No. J0255034 by FMC Corp. Available for reference at Bureau of Mines facilities in Denver, Colo., Twin Cities, Minn., Pittsburgh, Pa., 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 80–132814; paper copy price code A04.

OFR 3(2)–80. The Development of a Cross-Pit Overburden Handling System. Volume II—Appendix, by J. Ritchey, F. Hagenbuch, and J. Mantel. October 1976. 117 pp. 19 figs. This report describes the engineering feasibility and economic advantages of using a mobile bridge-type, cross-pit belt conveyor system in conjunction with a large dragline to excavate and transport spoils in a typical western surface coal mine. The studies show that such a system could be built to survive operational and climatic mining conditions, and that its implementation would offer a reduction in both acquisition and operating costs versus conventional mining units of comparable capacity. Reclamation costs can also be significantly reduced and the total reclamation process accelerated, making the cross-pit conveyor system attractive to mine owners and environmentalists alike. Research done under Contract No. J0255034 by FMC Corp. Available for reference at Bureau of Mines facilities in Denver, Colo., Twin Cities, Minn., Pittsburgh, Pa., 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 80–132822; paper copy price code A06.

OFR 4–80. The Influence of Mining Health and Safety and Environmental Legislation on Selected Domestic Metallic and Nonmetallic Minerals, by F. Albayrak, S. Lupton, T. McCrary, S. Mahmud, and G. Bierman. December 1978. 179 pp. 8 figs. This report is a study of the impact of Federal laws and regulations on the domestic supply of metallic and nonmetallic minerals. The study was confined to pertinent environmental legislation and the recently enacted Federal Mine Safety and Health Act of 1977. Legal requirements placed on individual selected mineral industries and the economic impact of these requirements are emphasized. Some attention was also directed toward particular environmental and health and safety problems generated by selected mineral industries. The study pinpointed a list of major problem areas that have a significant impact on the domestic mineral supply. Research done under Contract No. J0177124 by Science Applications, Inc. Available for reference at Bureau of Mines facili-

ties in Denver, Colo., Twin Cities, Minn., Pittsburgh, Pa., 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 80–131436; paper copy price code A09.

OFR 5–80. Development of Improved Multiseam Contour Haulback Mining, by Walter W. Kaufman and Wm. David Shrader. Mar. 30, 1979. 347 pp. 94 figs. This report summarizes a study conducted to develop improved techniques for haulback mining of multiple seam contour surface operations. The methods employed to perform contour haulback mining are discussed as are the implications of regulations requiring back to approximate original contour reclamation. Problems inherent to multiseam contour surface mines are defined and several potential solutions to those problems are introduced. Research done under Contract No. H0272025 by Skelly and Loy. Available for reference at Bureau of Mines facilities in Denver, Colo., Twin Cities, Minn., Pittsburgh, Pa., 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 80–149354; paper copy price code A15.

OFR 6–80. Study of Underground Coal Mine Waste Disposal Requirements in the United States, by Walter W. Kaufman and John R. Williams. Oct. 20, 1978. 250 pp. 17 figs. This report summarizes a study conducted to establish the nature and impact of regulations governing disposal of refuse from underground coal mines. The regulations affecting refuse disposal in eight major coal producing States are collected, summarized, and reviewed. Federal regulations applicable to refuse generated by underground coal mines are also included. Common refuse disposal practices are discussed as are the refuse quantities generated annually in each study State. Technical requirements of regulations are discussed and presented in tables. Economic implications are also assessed through cost analyses of three major types of disposal processes. The report also includes an assessment of future trends in regulation and refuse generation plus a series of recommendations concerning potential improvements in both the regulatory and refuse disposal processes. Research done under Contract No. J0275037 by Skelly and Loy. Available for reference at Bureau of Mines facilities in Denver, Colo., Twin Cities, Minn., Bruceton and Pittsburgh, Pa., 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 80–134646; paper copy price code A11.

OFR 7(1)–80. An Annotated Bibliography of Coal Mine Fire Reports. Volume I, by L. Bruce McDonald and Robert M. Baker. Feb. 15, 1979. 93 pp. 3 figs. This three-volume report describes the method whereby data were gathered and analyzed on coal mine fire reports. The primary objective of the program was to develop an annotated bibliography of coal mine fire reports (1950–77). Two additional objectives were to gather data on nonreportable fires and to conduct statistical analyses on the data to delineate trends. The report does not include explosions or ignitions or fires that resulted from explosives. Data were acquired from three major sources: periodicals, MSHA (Mining Safety and Health Administration) fire reports, and mine safety directors. The primary data source was MSHA fire reports contained in the files of MSHA coal mine health and safety district and subdistrict offices. Data were separated into reportable fires (at least 30 minutes duration or injury), nonreportable fires, and opinion data. The data were then analyzed by time trends, State, ignition source, burning substance, location, equipment, detection, duration, injuries, fatalities, and successful extinguishing agents. Volume I contains data acquisition procedures, data analysis procedures, and conclusions and recommendations. Research done under Contract No. J0275008 by Allen Corp. of America. Available for reference at Bureau of Mines facilities in Denver, Colo., Twin Cities, Minn., Pittsburgh, Pa., 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 80–140205; paper copy price code A05.

OFR 7(2)–80. An Annotated Bibliography of Coal Mine Fire Reports. Volume II, by L. Bruce McDonald and Robert M. Baker. Feb. 15, 1979. 400 pp. Volume II of this three-volume report presents data on underground and surface coal mine fires occurring between 1950–77. The report contains a master list of all fire incidents obtained from MSHA (Mining Safety and Health Administration) reports; an annotated bibliography of all MSHA reports, journal articles on selected incidents, and nonreportable fires; and indexes to be used in accessing incidents in the master list and annotated bibliography. These three types of information provide a complete summary of coal mine fires during the program and a convenient means to locate incidents of specific interest. Research done under Contract No. J0275008 by Allen Corp. of America. Available for reference at Bureau of Mines facilities in Denver, Colo., Twin Cities, Minn., Pittsburgh, Pa., 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 80–140213; paper copy price code A17.

OFR 7(3)–80. An Annotated Bibliography of Coal Mine Fire Reports. Appendix, by L. Bruce McDonald and Robert M. Baker. Feb. 15, 1979. 654 pp. This report is the appendix of a three-volume report that is intended to be used in conjunction with the tables and indexes contained in volume II, and as such should be considered an integral part of volume II. The indexes in the body of volume II provide a means of ready reference to the underground and surface mine incident report forms. For those readers with interests other than those indexed, tables II–1a and II–1b can be used to locate specific incidents of interest. Complete incident information can then be obtained from the corresponding report forms in the first two sections of this appendix. Research done under Contract No. J0275008 by Allen Corp. of America. Available for reference at Bureau of Mines facilities in Denver, Colo., Twin Cities, Minn., Pittsburgh, Pa., 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 80–140221; paper copy price code A99.

OFR 8(1)–80. Availability of Critical Scrap Metals Containing Chromium in the United States. Part 1. Superalloys and Cast Heat and Corrosion-Resistant Alloys, by LeRoy R. Curwick, Walter A. Peterson, and Harry V. Makar. November 1979. 114 pp. 11 figs. A study was conducted to assess the domestic availability of chromium from superalloy and cast heat- and corrosion-resistant alloy scrap material. Six alloy classes included in this survey were investment cast, hardfacing, and wrought nickel- and cobalt-base alloys, wrought nickel-iron-base alloys, and heat- and corrosion-resistant alloy castings. Data were collected for 1976 on metallic scrap generation, use patterns, and production practices for these alloy producing and using industries. A model was developed that allowed an assessment of the materials flow circuits that produce these alloys. The types, amounts, sources, secondary products, and ultimate destinations of chromium-containing metallic scrap for the six alloy classes were determined. Research done under Contract No. J0188056 by INCO Research & Development Center. Available for reference at the Bureau of Mines Research Center in Avondale, Md.; and the 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 8(2)–80. Availability of Critical Scrap Metals Containing Chromium in the United States. Part 2. Wrought Stainless Steel and Heat-Resisting Alloys, by C. L. Kusik, H. V. Makar, and M. R. Mounier. November 1979. 83 pp. 6 figs. As part of an effort to establish the extent of the domestic supply that could be exploited in case of adverse changes in international chromium production and trading patterns, this study was conducted for the Bureau of Mines to assess the domestic availability of critical scrap metals containing significant amounts of chromium. Data were collected on types of scrap, sources, amounts, and ultimate disposition, leading to the conclusion that in 1977 about 62,000 tons of contained chromium was unrecycled. Unrecovered obsolete stainless steel scrap accounts for most of these uncollected chromium values. In the methodology developed, chromium-containing metals are followed from the time they return as scrap. Data collected for 1977 and previous years are projected to 1990. Major losses are identified and estimated. Research done under Contract No. J0188170 by Arthur D. Little, Inc. Available for reference at the Bureau of Mines Research Center in Avondale, Md., and the 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 9(1)–80. Handbook for Surveys of Inhalation Contaminants in Above-Ground Metal and Nonmetal Mining and Processing Work Areas, by LFE Corp. Sept. 23, 1977. 87 pp. 4 figs. The objective of this handbook is to provide inspectors with guidance for recognizing hazards from inhalation contaminants in aboveground work areas of underground and surface metal and nonmetal mining and processing facilities and evaluating these hazards by collecting samples or making field determinations and interpreting the analytical results. Portions of the handbook that should prove most useful to the inspectors include a survey check list, rules for determining if sampling is required, list of most frequently encountered contaminants, list of candidate contaminants and their sampling conditions, interpretation of results, and a procedure for health and safety inspections. Research done under Contract J0255001. Available for reference at Bureau of Mines facilities in Denver, Colo., Twin Cities, Minn., Bruceton and Pittsburgh, Pa., 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 80–143969; paper copy price code A05.

OFR 9(2)–80. Surveying Inhalation Contaminants in Above-Ground Metal and Nonmetal Mining and Processing Work Areas. Instructor's Teaching Guide (For MSHA Inspectors), by Walter D. Holland. Sept. 23, 1977. 66 pp. 16 figs. This instructor's guide is intended for use in a course that teaches metal and nonmetal mine inspectors to perform surveys for inhalation contaminants in aboveground metal and nonmetal mine work areas. The handbook entitled "Handbook for Surveys of Inhalation Contaminants in Above-Ground Metal and Nonmetal Mining and Processing Work Areas" is used as a manual during the course. The manual contains a survey check list, rules for determining if sampling is required, a list of most frequently encountered contaminants, a list of candidate contaminants and their sampling conditions, and a description of control procedures and devices. There are several experiments in this guidebook that the trainees perform to acquaint them with the sampling systems. Research done under Contract No. J0255001 by LFE Corp. Available for reference at Bureau of Mines facilities in Denver, Colo., Twin Cities, Minn., Bruceton and Pittsburgh, Pa., 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 80–142938; paper copy price code A04.

OFR 9(3)–80. Surveying Inhalation Contaminants in Above-Ground Metal and Nonmetal Mining and Processing Work Areas. Instructor's Teaching Guide (For Company Safety Officers), by Walter D. Holland. Sept. 23, 1977. 81 pp. 16 figs. This is one of a series of instruction guides developed to help instructors present health and safety training courses to workers in the metal and nonmetal mining industry. This course is intended for training those, usually the safety officers, who perform surveys for inhalation contaminants in aboveground work areas. The handbook entitled "Handbook for Surveys of Inhalation Contaminants in Above-Ground Metal and Nonmetal Mining and Processing Work Areas" is used as a manual for the course and is a prime reference when performing the actual surveys or interpreting the sampling results. There are six experiments for the students to perform during the course to familiarize them with the sampling devices routinely used during the surveys. Research done under Contract No. J0255001 by LFE Corp. Available for reference at Bureau of Mines facilities in Denver, Colo., Twin Cities, Minn., Bruceton and Pittsburgh, Pa., 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 National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80–142946; paper copy price code A05.

OFR 10–80. Evaluation of Mine Parameters for Copper-Nickel Deposits of Northern Minnesota, by C. M. St. John, M. Christianson, and D. L. Peterson. Feb. 15, 1979. 112 pp. 54 figs. A series of analyses of possible mining excavations associated with the development of copper-nickel deposits of the MINNAMAX site in northeastern Minnesota is presented. Specific areas such as roof-and-pillar stability and excavation orientations are addressed. The majority of these analyses were conducted using a boundary element method but some cases were also analyzed using the finite element method. Comparable results were obtained using the two methods but the boundary element method required less data preparation time and computer run time. Results of the analyses, as well as indicating the capabilities of geotechnical numerical models, provide some insights into behavior around multiple excavations in jointed rock. Research done under Contract No. J0295003 by University of Minnesota. 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.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80–144074; paper copy price code A06.

OFR 11–80. Application of Satellite Data to Surface Mine Monitoring in Selected Counties of South Carolina, by James N. Bayne and Hewson Lawrence. March 1979. 141 pp. 67 figs. The objective of this investigation was to examine the applicability of Landsat digital image processing to surface mine monitoring in South Carolina. Landsat data from computer compatible tapes were used to explore the capability of Landsat digital imagery to monitor mining and reclamation activity in several South Carolina mining operations. Differentiation between active-spoil and partially and completely reclaimed areas was successfully demonstrated including small mining operations of less than 30 acres. Supervised sequential discriminant analysis and unsupervised classifications at Stanford University and a parallelepiped classifier at the EROS Data Center were used. A high degree of accuracy was obtained in measuring several mines and mine segments with each system. Research done under Grant No. G0177166 by the South Carolina Land Resources Conservation Commission. 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., 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 80–144629; paper copy price code A07.

OFR 12–80. Design, Fabrication and Demonstration of an Inert Gas Generator, by John T. Dieckmann and Steven K. Ruggieri. April 1979. 106 pp. 30 figs. This report presents the work performed and results obtained in a 2-year development of a mobile inert gas generator for use in the Bureau of Mines remote sealing system for fighting underground coal mine fires. The performance requirements of an inert gas generating system for the remote sealing system were clearly established. A review of seven possible system designs meeting these requirements was conducted. An air-cooled, distillate oil-fired combustion inert gas generator was selected for further detailed design, hardware fabrication, and performance testing. The inert gas generator was tested and has been operated in the field for approximately 200 hours and the system has met or exceeded all important performance requirements. Research done under Contract No. H0155053 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., 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 80–145881; paper copy price code A06.

OFR 13(1)–80. Survey of Surface Hydraulic Mining Technology. Volume 1—Final Report, by William C. Cooley and Viguen Ter-Minassian. July 30, 1976. 134 pp. 29 figs. A literature search and a survey were prepared on the technology of surface hydraulic mining with particular reference to its possible use in the United States for stripping overburden from surface coal mines. Extensive use was made of Russian references that were translated into English. The advantages and disadvantages of hydraulic mining and hydrotransport are identified as well as criteria for selecting potential applications. At present, the major U.S. application is in the phosphate industry of Florida and North Carolina. Potential locations for hydraulic stripping of overburden from coal seams are identified in Alaska, Illinois, Montana, Washington, and Wyoming. Other potential applications include the hydraulic mining of peat in Minnesota, and the stripping of overburden from lignite in Texas, Montana, North Dakota, and South Dakota. Further research is recommended, particularly on the subject of dewatering of fine clay slimes to avoid water pollution and to permit rapid reclamation of mined areas. Research done under Contract No. J0265016 by Terraspace, 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., 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. Copies of this report will not be available for purchase.

OFR 13(2)–80. Survey of Surface Hydraulic Mining Technology. Volume 2—Appendices to Final Report, by William C. Cooley and Viguen Ter-Minassian. July 30, 1976. 410 pp. 333 figs. A literature search and a survey were prepared on the technology of surface hydraulic mining with particular reference to its possible use in the United States for stripping overburden from surface coal mines. Extensive use was made of Russian references that were translated into English. The advantages and disadvantages of hydraulic mining and hydrotransport are identified as well as criteria for selecting potential applications. At present, the major

U.S. application is in the phosphate industry of Florida and North Carolina. Potential locations for hydraulic stripping of overburden from coal seams are identified in Alaska, Illinois, Montana, Washington, and Wyoming. Other potential applications include the hydraulic mining of peat in Minnesota, and the stripping of overburden from lignite in Texas, Montana, North Dakota, and South Dakota. Volume 2 comprises the appendixes. Research done under Contract No. J0265016 by Terraspace, 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., 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. Copies of this report will not be available for purchase.

OFR 13(3)–80. Survey of Coal Preparation Technology for Hydraulic Coal Mines, by David C. Nunenkamp and William C. Cooley. Sept. 30, 1976. 455 pp. 84 figs. A literature search and a survey were prepared on the technology of coal preparation for use with hydraulic coal mines that produce a higher-than-usual content of fine coal fractions, increasing the difficulty of cleaning, dewatering, water clarification, and refuse disposal. Extensive use was made of Russian references that were translated into English. A review of U.S. coal preparation practices was made and the changes were identified that would be required to handle coarse coal that is produced by a hydraulic coal mine or transported by pipeline as a coarse coal slurry. The problems are most severe when the coal contains fine colloidal clay impurities. Research is recommended on improvement of dewatering equipment such as centrifuges and on the direct utilization of coal slurry for combustion to avoid the expense of dewatering. Research done under Contract No. J0265016 by Terraspace, 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., 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. Copies of this report will not be available for purchase.

OFR 14–80. A Study to Determine the Manpower and Training Needs of the Coal Mining Industry, by John Short, Jeffrey Harris, Judith Waldo, and Sharla Barber. December 1979. 145 pp. 6 figs. In response to anticipated increases in the demand for coal and the corresponding need for a rapidly expanding mining work force, this report provides an assessment of the current and future training needs of the coal mining industry generated by that work force. Using Department of Energy forecasts and an employment-turnover model (developed under a previous Bureau of Mines contract), estimates of the existing and future number of training incidences are presented. The existing supply of training is explored, and the primary sources of training are identified (for example, coal companies, schools, government, etc.). By matching the existing training supply with the anticipated demand, recommendations for ensuring adequate levels of training for the future coal mine work force are made. Research done under Contract No. J0395038 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., 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 80–164742; paper copy price code A07.

OFR 15–80. Technical and Economic Evaluation of Underground Disposal of Coal Mining Wastes, by M. F. Bucek, J. K. Clauser, J. A. Schad, and N. K. Charkavorti. January 1980. 372 pp. 62 figs. This report presents the activities performed and the results achieved during a two-phase investigation of the technical and economic feasibility of disposing of coal mine refuse underground in active mines. Three regions that are severely affected by coal refuse problems are southwestern Pennsylvania, southern West Virginia, and eastern Kentucky. A conceptual model mine is presented that describes the geologic conditions, mining methods, and environmental circumstances typical of each region. Procedures used in selecting the regions and in modeling typical mines are described. The report presents existing methods for stowing systems that would be appropriate for the model mine, discusses technical characteristics and environmental effects relative to the various systems, and evaluates the technical and economic feasibility of the three alternative disposal system designs. Comparisons of costs among systems and with costs of surface disposal systems are presented. Research done under Contract No. J0285008 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., 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 80–154768; paper copy price code A16.

OFR 16(1)–80. The Three-Dimensional Structural Analysis of Double-Entry and Single-Entry Coal Mines. Final Report. Volume I. Three-Dimensional Finite Element Analysis of Crosscut and Entry Intersection of a Double-Entry Coal Mine, by M. B. Balanchandra. June 1976. 137 pp. 51 figs. The BMINES computer code was used to perform a three-dimensional finite element analysis of an instrumented section of a double-entry coal mine to provide a comparison between field measurements and existing analytic techniques. The sequence of excavation of the entries was considered as well as the installation of rock bolts and cribbing during the mining cycle. The materials in the region under investigation were idealized into four rock types and coal. The rocks were assumed to be isotropically elastic, perfectly plastic. Coal was represented by an elastically anisotropic (transverse isotropy) and plastically isotropic model. A fracture-yield criterion of the Coulomb form was used for all materials. The strength and stiffness of all materials were substantially reduced from available laboratory data to

account for in situ properties. Research done under Contract No. H0262020 by Agbabian Associates. Available for reference at Bureau of Mines facilities in Denver, Colo., Twin Cities, Minn., 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 80–150345;paper copy price code A07.

OFR 16(2)–80. The Three-Dimensional Structural Analysis of Double-Entry and Single-Entry Coal Mines. Final Report. Volume II. User's Guide for a Computer Program for Analytical Modeling of Rock-Structure Interaction, by Robert D. Ewing and Edward M. Raney. June 1976. 291 pp. 66 figs. The computer program described in this user's guide provides for the static, three-dimensional, linear and nonlinear analysis of structural and geological systems by the finite element method. The guide shows how input is prepared. A number of recent advances in finite element theory and computer technology are incorporated in the program. Nonlinear material properties are provided for including isotropic, anisotropic, and time-dependent material properties, gravity loading, simulation of a sequence of excavation or construction, and a slip or joint element. The finite elements include beam, rod, axisymmetric and plane quadrilateral, hexahedron, thick shell, and axisymmetric and plane joint. The program also has an automatic mesh generator to minimize user input preparation for continuum finite element meshes. Research done under Contract No. H0262020 by Agbabian Associates. Available for reference at Bureau of Mines facilities in Denver, Colo., Twin Cities, Minn., 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 80–150352; paper copy price code A13.

OFR 16(3)–80. The Three-Dimensional Structural Analysis of Double-Entry and Single-Entry Coal Mines. Final Report. Volume III. Three-Dimensional Finite Element Analyses of Single- and Double-Entry Portions of Sunnyside Mine No. 1, by D. E. Van Dillen. 278 pp. 56 figs. Three-dimensional structural analyses of three instrumented areas of a deep longwall coal mine were performed using the finite element code BMINES. The three instrumented areas include two single-entry portions and one double-entry portion of the Sunnyside No. 1 mine, Sunnyside, Utah. The finite element models simulated the sequence of excavation in each test area: the advance of the entry, installation of structural supports, retreat of the longwall, caving behind the longwall, and accumulation and loading of the gob. The structural supports considered in these finite element models include rock bolts, wood cribs, concrete cribs, steel arch sets, and chocks. Mechanical simulation of the geologic environment is achieved through elastic-perfectly plastic material models employing anisotrophy to represent finely layered regions of the medium. The results of these calculations are compared with the instrumentation readings from the mine. These measurements include closures, crib loads, rock-bolt forces, and stress growth. Research done under Contract H0262020 by Agbabian Associates. Available for reference at Bureau of Mines facilities in Denver, Colo., Twin Cities, Minn., 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 80–150360; paper copy price code A13.

OFR 17–80. Development of a Cross Pit Overburden and Waste Material Handling System, by Russell J. Gartrell and Thomas J. Crocker. January 1977. 75 pp. 27 figs. This report describes the engineering feasibility and economic advantage of using a steep-angle conveyance (SAC) system in conjunction with medium and large draglines to transport spoil in a typical western coal mine. The SAC system, including a receiving hopper, a steep-angle conveyor, and a stacker-spreader, is capable of processing overburden material at the rate of 7,000 tons per hour. The unique feature of this system is the steep-angle conveyor that transports the overburden material from the pit bottom to the top of the spoil at angles up to 45°. Compared with other means of cross-pit conveyance considered during this study, the SAC system offers the advantage of easier operation, lower cost, and greater mobility. The results of the study show that integration of the SAC system into both established and planned new mines would improve the overall mining operation, expand the operating capability of existing equipment, and reduce mining and reclamation costs. Research done under Contract No. H0252084 by R. A. Hanson Co., 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., 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 80–145998; paper copy price code A04.

OFR 18–80. Evaluation of Surface Mining Blasting Procedures, by Julius Roth, Keith C. Britton, Robert W. Campbell, and Warren R. Ketler. June 6, 1978. 162 pp. 8 figs. There are many potential hazards associated with surface blasting procedures that are not documented to a degree sufficient for the development and promulgation of safety standards. In addition, there are many operations where safer methods might be devised. The purpose of this program is to identify and document commonly used surface blasting practices and evaluate them in terms of their potential hazards with the objective of improving safety through the development of guidelines for safer blasting procedures in surface mining. Research done under Contract No. J0366017 by Management Science Associates. 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., 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 80–148653;paper copy price code A08.

OFR 19–80. Development of Interindustry Transactions Data on the Structure of United States Mining Industries for 1967 and a Comparison of Techniques for Updating Related Input-Output Coefficients, by H. Craig Davis and Everard M. Lofting. Apr. 30, 1979. 49 pp. This paper deals with two problems associated with input-output models: disaggregation and updating. National input-output models are commonly designed as general purpose models. Analysts with specialized interests will at times find that the segment of the economy on which their particular interests are focused is too highly aggregated. In this context, the procedure used for disaggregating the 7 mining sectors in the 1967 U.S. input-output table to 47 sectors is discussed. A second potential problem associated with input-output models arises from changes over time in the relationships between economic sectors. If the technical coefficients of the input-output model are not accordingly adjusted to reflect these changes, significant errors in the model's output may result The two most prominent techniques designed to update the input-output model's technical coefficients, the RAS and linear programing (LP) methods, are compared with regard to changes in U.S. national coefficients between 1963 and 1967. Research done under Grant No. G0122078 by University of California. 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 80–161425; paper copy price code A03.

OFR 20–80. The Input-Output Structure of the U.S. Mineral Industries for 1958 and 1963: Transactions, Employment, and Multipliers, by H. Craig Davis and Everard M. Lofting. April 1979. 60 pp. Input-output transactions tables for the economic years 1958 and 1963 for the United States are presented The tables were developed to show the detailed structure of the U.S. mineral industries at the 3- and 4-digit SIC code level. Output multipliers and types I and II employment and income multipliers were developed on a comparable basis and are presented for both years. Research done under Grant No. G0133091 by University of California. 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 80–160286; paper copy price code A04.

OFR 21–80. Economic Impact of the Phosphate Rock Industry on Selected Florida Counties, Florida, and the United States. by E. Ray Canterbery, Carl W. Hale, and E. Joe Nosari. September 1978. 101 pp. 2 figs. This report assesses the economic impact of the phosphate rock industry on selected counties in Florida, the State of Florida, and the United States. The research uses economic base analysis at the county level and industrial complex (input-output) analysis at the Florida and national level. A profile of the industry is also developed. Research done under Grant No. G0177120 by Florida State University. Available for reference at Bureau of Mines facilities in Juneau, Alaska, Denver, Colo., Pittsburgh, Pa., and Spokane, Wash.; and the National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Copies of this report will not be available for purchase.

OFR 22–80. Evaluation of Proximity Warning Devices, by J. E. Hipp, F. D. Henson, P. E. Martin, and G. N. Phillips. Feb. 22, 1980. 136 pp. 36 figs. Three electrostatic field sensing proximity warning devices were tested using full-scale cranes and powerline systems, a scaled model facility, environmental testing facilities, and theoretical-numerical analysis. The design objective of each device is to assist in safe crane operation near overhead powerlines. Several design deficiencies were noted, including inadequate overlap in sensitivity ranges, utilization of vacuum tubes and electromechanical parts, temperature sensitivity, and inaudible alarms. In addition, the testing showed major device limitations including sensitivity to boom orientations and length, polarization-dependent responses, and unreliable operation in the presence of multiple powerline circuits. The multiple powerline circuit problem is intrinsic to electrostatic sensing devices. The remaining deficiencies and limitations are correctable within a state-of-the-art design. Research done under Contract No. 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., 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 80–144413; paper copy price code A07.

OFR 23–80. Investigation of a Reliable Central Lubrication System for Underground Mining Equipment, by M. S. Fleming and C. Geopferich. August 1979. 73 pp. 15 figs. The objective of this investigation was to evaluate central lubrication systems for potential use on underground mining equipment. Previous use on continuous mining equipment resulted in poor system performance because of improper selection of lubricants, component failures, and an inconsistent delivery of lubricant to bearings. The principles and operational characteristics of systems are reviewed and evaluated, and it was concluded that systems are available that can provide a reliable central lubrication if properly applied, installed, and maintained. The procedures for applying a system to a continuous miner are discussed and recommendations are included for the continued development of systems for underground mining equipment. Research done under Contract No. H0282014 by Dayton T. Brown, 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., 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 80–149420; paper copy price code A04.

OFR 24–80. Determination of Breathing Zone Concentrations of Contaminants From Emissions From Diesel Powered Vehicles in Underground Mines, by Walter D. Holland. August 1978. 127 pp. 9 figs. The objective of this investigation was to determine miners' breathing zone concentrations of diesel exhaust components, to investigate any relationships between these concentrations and vehicle type, the

presence of emission controls, vehicle usage, and ventilation conditions, and to make recommendations for monitoring and ventilation requirements. Twenty-four mines including two coal mines were surveyed. Sampling was done for CO_x, NO_x, SO_x, PNA, aldehydes, and particulates. In most mines, concentrations of at least one contaminant exceeded one-half of the standard or threshold limit value. The concentrations of gases are probably sufficiently reduced by a minimum air velocity of 50 fpm. A sufficient reduction of particulate concentrations may require as high as 400 fpm air velocity. Vehicle age, type, or usage appear to have little or no effect on contaminant concentrations. Polynuclear aromatic levels were below detection limits in all but a very few samples. Minimum requirements for routine monitoring should include formaldehyde, CO_x, and NO_2. It is further recommended that better definition of the minimum ventilation requirement be obtained. Research done under Contract No. J0255001 by LFE 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., 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 80–150766; paper copy price code A07.

OFR 25–80. Cost and Time Analysis of the Mining and Environmental Requirements in the Premining Stage for Copper Mining in the Northern Highland, Wisconsin, by James P. Ludwig, Mervin C. Nelson, Catherine E. Ludwig, and Walfrid Been. Nov. 1, 1979. 185 pp. 26 figs. This report provides the results of a 2-year study of the projected time and cost requirements for new mine development in Wisconsin and is based on a unique blend of information from mining company officials, State regulatory agency officials, and contractor experience. Lists of the tasks and subtasks required to plan a new mine were developed and times and costs were assigned. Critical path method diagrams were then developed for a generalized mining project. Total time and cost for the premine planning process was estimated to be 25.12 years and 223 person-years of professional time excluding public affairs effort. By eliminating redundancies in the process and by increasing project efficiency through early public review and participation, recommendations were made to lessen the time and lower the cost of premine planning. The streamlining recommendations could shorten the overall critical path length to 17.16 years and lower the cost to 208 person-years of professional time excluding public affairs effort. The estimated distribution of professional effort for mine planning in Wisconsin approximates 50.5 pct for traditional mine and engineering tasks, 36.6 pct for environmental-regulatory tasks, and 12.9 pct for traditional geological-exploration tasks. Research done under Contract No. J0275011 by Mervin C. Nelson & Associates, Inc., and Ecological Research Services, 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 80–159163; paper copy price code A09.

OFR 26–80. Low Velocity Performance of Anemometers, by L. P. Purtell. May 1979. 170 pp. 100 figs. To meet the need for a calibration capability with adequate accuracy at low air velocities, the performance of 10 anemometers of several types has been measured. Multiple calibration runs provided sufficient data for measuring random errors about the mean calibration curve in addition to the difference between indicated and true speeds. Measurements were also performed of the minimum operating speeds of the anemometers. This report summarizes the results and presents analyses of the instruments' performance. Research done under Contract No. H0166198 by National Bureau of Standards. 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., 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, Washintgon, D.C. Order ONLY from NTIS: PB 80–158801; paper copy price code A08.

OFR 27–80. Polychlorinated Biphenyls: Regulations and Substitutes. A Compliance Manual for the U.S. Mining Industry, by Robert A. Westin, Robert P. Burruss, and Bruce Woodcock. Sept. 28, 1979. 89 pp. 8 figs. Polychlorinated biphenyls (BCP's) have been widely used 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 and heat transfer fluids and are present in many oil-filled transformers. The 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. Research done under Contract No. J0177046 by Versar 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., 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.

OFR 28–80. Development of a Dual-Boom Semi-Automated Roof Bolter, by C. Hellar, W. Elliott, and D. Hamilton. Aug. 31, 1979. 49 pp. 11 figs. Recognizing the hazards associated with roof bolting in underground coal mines, and the need for improved technology to reduce these hazards, the Bureau of Mines entered into an agreement with contractors to build a production model, second-generation automated bolter that would utilize the basic technology of remotely conrolled single-boom bolters. This report describes a new dual-boom, remotely controlled roof bolter that was designed, fabricated, and tested in an underground coal mine. Research done under Contract No. H0166138 by FMC 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., 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 80–158793; paper copy price code A03.

OFR 29–80. Aluminum and Silicon Interference During the Carbon Monoxide Reduction of Laterite Ores To Extract Nickel and Cobalt, by Dhanesh Chandra and Jacqueline Battles. August 1979. 102 pp. 28 figs. The report describes a study that was performed to better understand products extracted from low-grade domestic laterites using a carbon monoxide reduction and ammonia-ammonia sulfate leach. This understanding was gained through concerted applications of a combination of electron and optical microscopy, electron beam microanalyses, and X-ray techniques that revealed factors influencing low nickel extraction yields from certain laterites and the beneficial effect from the addition of sulfur compounds and halides. Research done under Grant No. G0274007 by University of Denver. 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.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80–162282; paper copy price code A06.

OFR 30(1)–80. Microseismic Monitoring of a Longwall Coal Mine. Volume I—Microseismic Field Studies, by H. Reginald Hardy, Jr., Gary L. Mowrey, and Edward J. Kimble, Jr. Aug. 31, 1978. 319 pp. 110 figs. Volume I of this three-volume report describes the detailed aspects of the microseismic field study conducted at a longwall coal mine at Greenwich Colleries, Barnesboro, Pa. The objectives of the study were to evaluate the feasibility of detecting microseismic activity originating from longwall mining operations using an approximately planar, near-surface, geophone array installed above the longwall and to attempt to locate sources of the various microseismic events. The investigation proved that using the techniques developed, it is possible to detect microseismic events at depths of more than 400 feet and at horizontal distances in excess of 800 feet from the source. Research done under Grant No. G0144013 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., 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 80–163397; paper copy price code A14.

OFR 30(2)–80. Microseismic Monitoring of a Longwall Coal Mine. Volume II—Determination of Seismic Velocity, by H. Reginald Hardy, Jr., and Laurance A. Beck. Oct. 31, 1977. 232 pp. 70 figs. Volume II of this three-volume report describes the evaluation of a number of different field techniques and the seismic velocity data obtained at the Greenwich Colleries, Barnesboro, Pa., mine site where microseismic studies were carried out. Three methods were employed to evaluate seismic velocities; namely, surface refraction, downhole, and transmission. In all cases the seismic sources were either located on surface (mechanical impact) or near-surface (explosive charges). It was found that a mechanical source could be conveniently utilized to determine shallow velocities and make bedrock-regolith interface depth determinations. For deeper velocity determinations suitable explosive charge sources were required. In general, refraction data did not always plot in a linear manner and some subjective interpretation was necessary. The downhole method was useful for incremental vertical evaluation; however, the transmission method provided the most consistent average vertical velocity data. Research done under Grant No. G0144013 by Pennsylvania State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., Rolla, Mo., 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 80–163405; paper copy price code A11.

OFR 30(3)–80. Microseismic Monitoring of a Longwall Coal Mine. Volume III—Field Study of Mine Subsidence, by H. Reginald Hardy, Jr., Bassam A. Anani, and Abdul W. Khair. Oct. 31, 1977. 140 pp. 38 figs. Volume III of this three-volume report presents the observed microseismic activity with surface subsidence. Field measurements of subsidence carried out at the Greenwich Colleries, Barnesboro, Pa., mine site are described. Comparative analysis of actual field results with data obtained using empirical and finite element techniques was undertaken. Comparison of field results with published National Coal Board data revealed marked differences. The influence of stronger rock beds overlying the coal seam in the current study was assumed to be the main cause. Use of the Gaussian profile resulted in a satisfactory fit to the field data, provided the value of the maximum field subsidence was used in the analysis. In general, when low tensile strengths were assumed for the associated rocks, finite element techniques gave results that compared well with the field data. The study also indicated that at shallow depths there is a marked difference in subsidence over dip and rise sides of the coal face, maximum subsidence is shifted more towards the dip side. Finally, time-dependent deformations were insignificant shortly after mining operations ceased. Research done under Grant No. G0144013 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., 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 80–163413; paper copy price code A07.

OFR 31–80. Research on the Hydrology and Water Quality of Watersheds Subjected to Surface Mining. Phase I: Premining Hydrologic and Water Quality Conditions, by Gary E. McIntosh and W. R. Hamon. Dec. 22,

1979. 35 pp. 6 figs. Five watersheds, ranging in size from 29 to 52 acres, were selected in east-central Ohio to study the hydrologic and water quality conditions occurring before, during, and after surface mining. The average concentrations of the water quality parameters for all watersheds were as low or lower than the Environmental Protection Agency recommended maximum allowable concentrations in drinking water except for suspended solids. Premining ground water systems for each watershed were found to have two major perched aquifers within the top 250 feet. Recharge is mostly from local precipitation and discharge is mostly as spring flow, stream baseflow, evapotranspiration, or leakage through the underlying confining bed. The shallowest ground water is commonly of the calcium bicarbonate type; whereas, water in the deeper aquifers is of variable type. Although dissolved-solids concentration is generally 200 to 600 mg/l, brackish or salty ground water is present in several areas. A one-dimensional unsaturated flow model was developed for interfacing with a quasi-three-dimensional ground water model as part of a projected composite hydrologic model. The unsaturated flow model includes provisions for an evapotranspiration model. Research done under Contract Nos. J0166054 and J0166055 by U.S. Department of Agriculture and Ohio Agricultural Research and Development 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., 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 80–159510;paper copy price code A03.

OFR 32–80. Dewatering Systems for Surface Coal Mines, by J. E. O'Rourke and K. O'Connor. Dec. 21, 1979. 260 pp. 50 figs. This report presents a review of available dewatering technology and an evaluation of its relevance to surface coal mines in the interior province of the United States. Guidelines for the selection, design, and construction of dewatering systems are included. On the basis of documented experience, candidate dewatering systems were selected and evaluated with respect to their anticipated impact on the environment and mine operations. Included in the discussion is a summary of laws and regulations that can impact on dewatering operations. Geologic and hydrogeologic conditions within the interior province are described and potential dewatering problems at surface coal mines are identified. Model mines were developed that exhibit the most difficult dewatering problems, and it is demonstrated how available technology can be utilized to deal with them. Dewatering of coarse-grained, high permeability terrace deposits might be economically feasible. Low permeability, saturated glacial tills or lake deposits appear to be significantly outside present economic feasibility for dewatering. Research done under Contract No. J0275025 by Woodward-Clyde Consultants. 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., 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 80–160153; paper copy price code A12.

OFR 33–80. Fire-Resistant Hydraulic Fluid Safety, by E. C. Fitch and J. S. Campbell. Aug. 3, 1979. 51 pp. 15 figs. This report discusses fire-resistant hydraulic fluid safety from three different directions. First, results of a survey prepared for the Fire Resistant Hydraulic Journal by the staff of the Fluid Power Research Center are analyzed. Second, operational limitations of fire-resistant hydraulic fluids are examined. Finally, laws and standards of various foreign countries are investigated. The results show that a significant number of experts in the fluid power industry are not in agreement about aspects of fire-resistant hydraulic fluid fire-resistance and toxicity. This indicates a need for more in-depth research. The use of fire-resistant hydraulic fluids involves a compromise between the decreased fire hazards and increased toxicity and machine incompatibility problems. Major foreign governmental agencies have thorough laws and standards concerning fire-resistant hydraulic fluids. These laws and standards may provide a solid framework for further international research into fire-resistant hydraulic fluid safety. Research done under Contract No. J0188129 by Oklahoma 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., 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 80–159486; paper copy price code A04.

OFR 34–80. Develop Safety Practices for Electrokinetic Treatment of Mine Waste, by Charles E. Green. July 1979. 75 pp. 3 figs. This study was conducted to identify, evaluate, and develop procedures to minimize or eliminate safety hazards associated with the electrokinetic dewatering process such as toxic and volatile gas emissions, electrical shock, accidental detonation of explosives, electromechanical corrosion of metal appurtenances, and possibly others. The study was based on pertinent literature, existing safety regulations, interviews with mine personnel, physical and mechanical properties of the electrokinetic dewatering process, and physical characteristics of the material to be dewatered. The electrokinetic dewatering process was described and potential safety hazards were identified and evaluated. Procedures and/or safety regulations were developed to minimize or eliminate the potential hazards. It was recommended that the electrokinetic dewatering process, when used in deep metal mines, be properly monitored to obtain additional information on other potential hazards. Research done under Contract No. H0272005 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., 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: AD-A072925; paper copy price code A05.

OFR 35–80. Positive Indicator for Track Switch Point Position, by Andrew St. Amant. Feb. 28, 1978. 34 pp. 14 figs. The objective of this research was to develop and test a fail-safe device that would provide positive indication of track switch point position and be suitable for application in contemporary underground coal rail haulage systems. The effort was divided into four phases as follows: (1) evaluation, (2) design, (3) fabrication and surface testing, and (4) underground installation and testing. The results are described in Section 2 of the report and a sequential listing of the 53 steps employed in developing the system is Appendix A. Research done under Contract No. H0166046 by MBAssociates. 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., 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 80–160815; paper copy price code A03.

OFR 36–80. A Study of Roof Falls in Underground Mines on the Pocahontas #3 Seam, Southern West Virginia and Southwestern Virginia, by John C. Ferm, Robert A. Melton, Gloria D. Cummins, David Mathew, Linda McKenna, Charles Muir, and G. Norris. September 1978. 92 pp. 26 figs. This report summarizes the results of an investigation of geologic factors that contribute to roof quality in underground mines in the Pocahontas No. 3 coalbed in southern West Virginia and southwestern Virginia. The investigation consisted of three phases. The first was selecting for detailed study five mines that represented the range of roof conditions, mining practices, and geologic phenomena. This was accomplished by a statistical analysis of questionnaire data from 35 mines. The second consisted of detailed mapping in a "good" and a "bad" top area in each of the mines and resulted in a qualitative assessment of the geologic factors contributing to roof falls. In the third phase, five mines were selected in which most nongeologic factors believed to contribute to roof falls were relatively constant but displayed a wide variety of assessments from phase II. The primary result of this investigation is that slickensides arising from different geologic causes are the major geologic features leading to roof falls. These slickensides are found in ancient slump deposits, fire clays and sandy fire clays, and channel contacts. Falls also occur where thick sandstone bodies directly overlying the coal contain abundant shale or ironstone pebbles and coaly strips. The best top material is a sequence that consists of shale grading upward to sandy shale and sandstone within 30 feet of the top of the coal. Thick sandstone units without pebbles also provide good top material. Research done under Contract H0230028 by University of South Carolina. 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., 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 80–158983; paper copy price code A05.

OFR 37–80. Mineral Appraisal of the Proposed Utukok and Colville Wild and Scenic Rivers: A Summary Report, by Staff, Alaska Field Operations Center. Apr. 2, 1980. 8 pp. 2 figs. This is one of a series of summary reports that present the findings of reconnaissance-type mineral assessments of certain lands in Alaska. The Utukok and Colville Rivers rise near the eastern end of the De Long Mountains in the southern part of the National Petroleum Reserve-Alaska (NPR-A). Historically, both have been important surface travel routes. NPR-A has been closed to mineral entry since the 1920's. The Utukok River heads in a little known part of a mineralized trend characterized by stratiform zinc-lead-silver deposits with barite and fluorite. Exposures of coal, mostly bituminous, are known along the Utukok River generally from Archimedes Ridge and Carbon Creek downstream to the mouth. The Colville River valley is north of any recognized metallic mineral trends although most tributaries from the south head into mineralized areas. Dominantly bituminous coal occurrences are known from the mouth of the Etivluk River downstream to within 20 miles of Umiat. Subbituminous coals have been reported at intervals from there to the Beaufort Sea. Both the Utukok and Colville drainage basins have rock environments similar to those in which sedimentary uranium deposits occur elsewhere, but this possibility remains unevaluated. 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 the 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 38–80. Mineral Investigations of the Misheguk Mountain and Howard Pass Quadrangles, National Petroleum Reserve-Alaska, by Uldis Jansons and Donald W. Baggs. Apr. 2, 1980. 76 pp. 11 figs. The 1977 Bureau of Mines mineral investigation program in the National Petroleum Reserve-Alaska (NPR-A) was designed to make a preliminary evaluation of known and reported mineral showings, a followup on the U.S. Geological Survey's 1977 regional geochemical results, and sample color anomalies—those due to oxidation of iron. Eighteen separate areas were examined during the 1977 field season. Significant mineralization was found at only one site, the Drenchwater Creek area, where concentrations of base metal sulfides occur in and near outcrop. The zinc-lead-silver bearing zone has been traced along strike and is at least 6,500 feet long and may possibly extend more than 10,000 feet. Minor mineralization has been found at other sites. These include fluorite at Mount Bupto, chromite at Siniktanneyak Mountain, and barite nodules near Safari Creek. 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 the 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 39–80. Remote Operator Coal Mine Roof Bolter Concepts Utilizing Existing Techniques and Components, by G. Hakes and T. Haviland. September 1978. 169 pp. 37 figs. A data bank on bolter technology was assembled that included the state-of-the-art industrial equipment as well as new equipment currently under development for the Bureau of Mines. This information was augmented by visits to Bureau of Mines contractors, mine operators, and others to obtain a thorough understanding of present coal mine roof bolting safety and productivity problems. Using this background material and information, a series of roof bolter concepts was developed offering improved operator safety with minimum impact on productivity. The concepts developed utilize existing componentry and technology wherever possible. All of the concepts feature a fully protected operator station located 6 to 10 feet outby the active bolt line and the hazardous rotating machinery. Research done under Contract No. H0272028 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., 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 80–167455; paper copy price code A08.

OFR 40–80. Effectiveness of Inclined Roof Bolts in Coal Mines, by Madan M. Singh. July 1978. 115 pp. 38 figs. This report presents the results of an investigation of inclined roof bolts, anchored over pillars, in room-and-pillar coal mines susceptible to shear failures of the roof. Although the field data do not support this contention, it is believed on the basis of analyses and other work that inclined roof bolts do offer potential under some circumstances. Research done under Contract No. J0275031 by Engineers International, 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., 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 80–167430; paper copy price code A06.

OFR 41–80. Underground Vibrations From Surface Blasting at Jenny Mine, Kentucky, by Dennis E. Jensen, Robert D. Munson, Lewis L. Oriard, Jan D. Rietman, and Robert S. Wright. Nov. 1, 1979. 102 pp. 33 figs. As part of the Bureau of Mines program to develop criteria for the proximity of surface blasting to underground mines, field studies were performed during blasting operations for strip coal mining above room-and-pillar workings at Jenny mine in eastern Kentucky. Measurements and observations were made to identify physical changes in the mine. No change in the frequency of roof falls or any other indications of apparent damage was noted. Recordings of blast-induced vibrations were made using sensors on the roof and floor of the underground mine and at the ground surface. A maximum particle velocity of 17.5 inches per second was recorded on the mine roof. The vibration data were analyzed and comparisons were made between roof vibration levels and those recorded on the mine floor and at the ground surface. Results are compared with previous blast vibration studies. Recommendations are made for further study toward developing criteria. Research done under Contract No. J0275030 by Woodward-Clyde Consultants. 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., 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 80–168925; paper copy price code A06.

OFR 42–80. Mineral Deposits of the Cape Krusenstern Area, Alaska: A Preliminary Comment, by Staff, Alaska Field Operations Center. 1980. 19 pp. 3 figs. The geology of the Cape Krusenstern area has been mapped on a 1- to 1-million scale by the Geological Survey. Mining claims were mapped and data on private and Government-sponsored mineral exploration was compiled. The Energy Research and Development Administration had sampled waterborne sediments during a reconnaissance for uranium. Although the Bureau of Mines has done no field work in the area except for a very brief visit in 1976, the Bureau did arrange to have these samples analyzed for metallic and related elements. The resultant sample analyses and all other available data on mining and prospecting activity were considered in relation to the geology. The combined data indicates that lead, zinc, silver, tin, gold, nickel, and platinum-group metals occur in the area in amounts that warrant field investigation. 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 43–80. Fortymile Placer District Resource Inventory, Alaska, by Douglas B. Colp. 1980. 16 pp. 10 figs. The Fortymile placer district comprises the Alaska part of the Fortymile River drainage basin, the Eagle district, and the Seventymile River drainage basin. Most of the district is underlain by Precambrian and Paleozoic gneiss and schist, of both sedimentary and igneous origin and minor crystalline limestone, and by Paleozoic, Mesozoic, and Tertiary felsic, mafic, and ultramafic igneous rocks. Gold in the placers is the result of weathering away of many mineralized quartz veins in metamorphic rocks near contact with felsic intrusive bodies. This report presents a resource inventory based on records research, visits to various parts of the Fortymile area, information accumulated by miners, personal interviews, and other publications. Research done by Alaska Field Operations Center. Available for reference at Bureau of Mines facilities in 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 44–80. Testing the Effects of Applied Behavioral Analysis and Applied Behavioral Management

Techniques on the Safe Behaviors of Salt Mine Personnel, by S. Stephen Uslan, Harvey M. Adelman, and Robert S. Keller. Sept. 30, 1978. 44 pp. 8 figs. The purpose of this study was to demonstrate the effect of positive reinforcement, specifically, social reinforcement (SR) on the frequency of eye, hand, and back injuries at four experimental salt mines. Injury data were collected from January 1976 through September 1978 on a month-by-month basis. Approximately 100 managers and supervisors were trained in the use of positive reinforcement of occurrences of "safe behavior." Each was provided with manuals and other supportive materials and following training, they were provided coaching experience to help retain the knowledge and capabilities gained. The analysis showed significant injury reductions at two sites and no reductions at the other two. When the data were corrected for the work-hours expended in the post training period, a third site showed reductions in injuries. Similar findings were shown when the experimental sites were compared with other sites in the industry. The results support the hypothesis that the application of SR is related to a reduction in injuries. Research done under Contract No. J0166137 by the Salt Institute and Human Potential Development Corp. Available for reference at Bureau of Mines facilities at 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. 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 80–171309; paper copy price code A03.

OFR 45–80. A Suggested Experimental Plan for the Determination of the Accuracy and Reliability of Coal Mine Dust Measurements, by Harry H. Ku and Joan R. Rosenblatt. October 1979. 48 pp. The work in this study was done under an agreement with the National Bureau of Standards and the Bureau of Mines with the objective to determine the accuracy and reliability of dust measurements when taken with the current equipment by coal miners in underground mines. The work is to be conducted in two phases. The first is to develop an experimental plan to determine the accuracy and reliability of coal mine dust measurements at three levels of funding and will serve as a basis for the second phase in which the experimental work will be conducted. Research done under Contract No. J0177013 by National Bureau of Standards. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., 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 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 80–173891; paper copy price code A03.

OFR 46(1)–80. Design Criteria for Roof Bolting Plans Using Fully Resin-Grouted Nontensioned Bolts To Reinforce Bedded Mine Roof. Volume I. Executive Summary and Literature Review, by J. C. Gerdeen, V. W. Snyder, G. L. Viegelahn, and J. Parker. July 22, 1977. 208 pp. 83 figs. The objective of this investigation is to identify factors governing the effectiveness of roof bolting systems using fully resin-grouted nontensioned bolts for reinforcement of bedded mine roofs and to develop design criteria for such plans. Volume I presents a summary of work done, a background study, and a literature review on resin bolting, mine analysis, and coal and rock properties. Strength and stiffness properties of resin bolts under both axial and shear loadings are considered in detail. Mechanisms of roof reinforcement using resin bolts are reviewed. Associated mine analyses including the effects of in situ conditions are included. Research done under Contract No. J0366004 by Michigan Technological 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., 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 80–180052; paper copy price code A10.

OFR 46(2)–80. Design Criteria for Roof Bolting Plans Using Fully Resin-Grouted Nontensioned Bolts To Reinforce Bedded Mine Roof. Volume II. Field Survey, by J. C. Gerdeen, V. W. Snyder, G. L. Viegelahn, and J. Parker. July 22, 1977. 167 pp. 125 figs. This report presents field surveys obtained during visits to 38 mines, in the United States and abroad, 4 resin manufacturers, universities, and other research facilities to gain knowledge of roof control problems, the use of resin bolting to overcome those problems, and the shortcomings of resin bolting. Research done under Contract No. J0366004 by Michigan Technological 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., 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 80–180060; paper copy price code A08.

OFR 46(3)–80. Design Criteria for Roof Bolting Plans Using Fully Resin-Grouted Nontensioned Bolts To Reinforce Bedded Mine Roof. Volume III. Experimental Model Studies, by J. C. Gerdeen, V. W. Snyder, G. L. Viegelahn, and J. Parker. July 22, 1977. 128 pp. 45 figs. The report presents experiments that were run on adhesion of resin to rock, pull tests of resin anchored rebars, and bending tests of thinly laminated beams reinforced with resin bolts. The effects of hole diameter, bolt diameter, resin annulus, and hole conditions on anchorage, and the effect of bolt spacing on beam bending were determined. Research done under Contract No. J0366004 by Michigan Technological 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., 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 80–180078; paper copy price code A07.

OFR 46(4)–80. Design Criteria for Roof Bolting Plans Using Fully Resin-Grouted Nontensioned Bolts To Reinforce Bedded Mine Roof. Volume IV. Theoretical Analysis, by J. C. Gerdeen, V. W. Snyder, G. L. Viegelahn, and J. Parker. July 22, 1977. 81 pp. 41 figs. Investigations were conducted on axial and shear loading of resin bolts, the Voussoir rock arch, beam building, angle bolted roof trusses, jointed roofs, bolting of sloping joints, and stresses in roofs due to moisture changes. The analyses described here are supplemental to those described in volume I. Research done under Contract No. J0366004 by Michigan Technological 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., 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 80–180086; paper copy price code A05.

OFR 46(5)–80. Design Criteria for Roof Bolting Plans Using Fully Resin-Grouted Nontensioned Bolts To Reinforce Bedded Mine Roof. Volume V. Synthesis and Design Criteria, by J. C. Gerdeen, V. W. Snyder, G. L. Viegelahn, and J. Parker. July 22, 1977. 129 pp. 104 figs. The design synthesis and the establishment of design criteria presented in this report is based on a critical review of the first four volumes of the report. The design synthesis points out some practical aspects of roof control using bolting but definitive design criteria were not obtained. The current Code of Federal Regulations Title 30, Part 75, is examined and recommended modifications are given. Research done under Contract No. J0366004 by Michigan Technological 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., 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 80–180094;paper copy price code A07.

OFR 47(1)–80. Interpretation of Rock Mechanics Data (Vol. I.) (A Two-Dimensional Finite Element Approach to the Evaluation of Underground Coal Mine Stability), by W. G. Pariseau. June 30, 1978. 172 pp. 99 figs. A two-dimensional finite element program was modified and extended to account for some of the rock mechanics complexities associated with single-entry development of longwall coal mine panels. The program includes arbitrary assignment of element properties without regard to element ordering, anisotropic elastic, plastic and brittle rock properties that may be time-dependent (aging), arbitrary mining sequences, and provisions for the effects of artificial support on the adjacent strata. Failure is according to an extended von Mises criterion that may be linear or quadratic in form; flow rules are obtained from the yield function taken as the plastic potential, but brittle behavior is treated as a discontinuous process of material properties change with deformation. The extent of failure is calculated from the external boundary conditions. Application of the program to essentially two-dimensional problems resulted in close agreement between calculated displacements and field measurements in the double-entry system. Bleeder entries were stable in one locality and not in another. Artificial support had little influence on stability. Research done under Contract No. H0220077 by the University of Utah. 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., 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. Copies of this report will not be available for purchase.

OFR 47(2)–80. Interpretation of Rock Mechanics Data (Vol. II.) (A Guide to Using UTAH2), by William G. Pariseau. June 30, 1978. 41 pp. 18 figs. A brief description of a two-dimensional elastic-plastic finite element program intended for mine stability analysis is presented that includes detailed instruction for input data preparation and how to obtain output. Research done under Contract No. H0220077 by the University of Utah. 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., 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. Copies of this report will not be available for purchase.

OFR 48–80. Field Test of Chemical Injection for Stabilizing Coal Mine Roof, by H. W. Brandt. December 1977. 57 pp. 5 figs. A field test was designed to inject a specially formulated two-compound epoxy resin into the roof rock ahead of a working face to cement fractures and formation interfaces at the Westmoreland Coal Co.'s No. 5 mine, Eccles, W. Va. Five 30-foot-long by 2-inch-diameter holes were drilled at a 10° angle above the plane of roof line from the face of a working entry. The epoxy resin compounds were pumped through a proportioning unit and mixed in-line before being discharged into the drill hole at injection pressures up to a maximum of 450 psig. When the coal face was advanced, an anomolus failure of roof rock occurred in the treated section. Further testing was suspended until the cause of the failure could be determined. The polymers were tested under confined conditions in 2-inch pipe columns. Extreme temperature and pressure up to 2,400 psig rises were recorded as they cured. It was concluded that this pressure source fractured the rock and caused the roof failure. The entire program was terminated after it was determined that the heat rise and resultant high pressures could not be controlled chemically or mechanically. Research done under Contract No. H0252034 by McCarthy Engineering & Construction, 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., 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. Copies of this report will not be available for purchase.

OFR 49–80. Evaluation of Chemical Agents for Inhibiting Acid Mine Drainage Formation, by John W. Nebgen and Douglas F. Weatherman. April 1979. 128 pp. 31 figs. This report contains findings from a Bureau of Mines study concerning the inhibition of acid mine drainage formation from underground coal mines. A series of experiments was performed in which three different pyritic materials (wastes from coal production plants) were evaluated using several candidate inhibiting agents. Data obtained from the inhibitor-treated pyrites were compared with data from control experiments in which untreated pyritic wastes were used. The experiments were conducted by placing treated and untreated pyrite in columns, passing moist air through the columns to promote oxidation of pyrite, and washing the columns weekly to collect oxidation products for analysis. The results indicate that quantities of acid mine drainage can be substantially reduced if soluble iron III (ferric) ion is controlled. Research done under Contract No. J0366036 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., 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 80–176357; paper copy price code A07.

OFR 50–80. The Field Testing of Several Mine Roof Fall Alarm Systems in an Anticipated Natural Roof Fall in the White Pine Mined-Out Windpipe Area, by Walter L. Finlay. June 30, 1978 96 pp. 39 figs. The Bureau of Mines has developed prototype instruments promising to improve the ability to warn of imminent roof falls. An unusually good opportunity to test these comparatively under natural caving conditions was afforded by the forecasted caving in August 1977 of a mined-out region of the White Pine mine where the rock strata closely resembles those in many coal mines. The anticipated cave was of the competent roof-weak-pillar type and occurred as and when predicted. Automated convergence and bed separation gages agreed well with the standard manual convergence gage measurements. A microseismic gage was insensitive to the fall and may require different test conditions for effectiveness. A roof resistivity unit was tested under a separate Bureau of Mines contract. An unplanned addition to the field test, the tiltmeter, showed interesting potential. Research done under Contract No. H0272036 by White Pine Copper 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., 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 80–174261; paper copy price code A05.

OFR 51–80. An Investigation of the Interaction of Rock and Types of Rock Bolts for Selected Loading Conditions, by Charles J. Haas, Robert L. Davis, H. Dean Keith, Janakkumar Dave, Wesley C. Patrick, and Jack R. Strosnider, Jr. June 15, 1976. 398 pp. 222 figs. This report presents five aspects of the interactions of rock bolts and surrounding rock to support coal mine roofs: (1) A finite element analysis of the bolted mine roof structure including the affects of bedding planes, inclined fractures, lateral stress, and bolt type (expansion anchored and fully grouted). (2) Theoretical and experimental studies of a split-ring forced into an undersize hole (split-set rock bolt) with elastic and plastic solutions. (3) Laboratory shear tests on resin-grouted bolts and split-set tubes with anchors with smooth and rough shear planes in limestone and shale rock. (4) Laboratory creep tests on resin-grouted bars to determine the initial load bleed off, creep under constant axial load, pull out stiffness, and ultimate strength. (5) Field tests with resin-grouted bolts instrumented with strain gages and placed in a coal mine roof. Roof sag stations were also installed in an attempt to relate bolt loading to vertical strata movement. Research done under Contract No. H0122110 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., 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. Copies of this report will not be available for purchase.

OFR 52–80. Modeling of the Leaching of Copper Oxide Ores, by Dong G. Chae and Milton E. Wadsworth. Dec. 31, 1979. 62 pp. 16 figs. A model for the leaching of oxide ores is developed and correlated with laboratory tests for percolation leaching of copper oxide ore. Using the model, recovery of metal values and lixiviant concentration of the effluent solution at any time may be evaluated. For the copper oxide ore, a simplified version of the model is examined for the leaching mechanism consisting of (1) a surface flush reaction with the highest rate of lixiviant consumption, (2) penetration of the lixiviant to react with copper minerals and gangue constituents, and (3) slow lixiviant consumption mostly by residual gangue materials. The simplified model is able to explain reasonably the leaching behavior of copper oxide ore by introducing a concept of effective initial size to correct for packing in a bed of fine particles. Research done under Grant No. G0166022 by University of Utah. 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.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80–179120; paper copy price code A04.

OFR 53–80. Resistivity Roof Fall Warning System in the White Pine Mine, by Michael Gibbons, A. J. Farstad, and R. F. Kehrman. Mar. 15, 1979. 75 pp. 41 figs. A method of monitoring roof stability in underground mines by detecting the changes in resistivity of roof material was tested. The device was tested over a 16-month period at the White Pine

copper mine in Michigan. Three falls of ground were monitored by as many as 11 sensors. Data indicate a correlation between changes in resistivity and impending structural failure. Problems were encountered with the high roof electrode impedance in the winter and spring due to the drying out of the roof material. Difficulties also developed in obtaining a permanent bond between the roof rock, the conductive epoxy, and the electrode plate. Some data were lost due to timer and fuse problems within the unit, but these were eventually rectified. Research done under contract H0272037 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., 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 80–186547; paper copy price code A04.

OFR 54–80. Natural Cementation of Retorted Oil Shale, by Clifford B. Farris. May 1979. 131 pp. 20 figs. The natural cementation strength of retorted oil shale is the focus of this study. The optimum retorting temperature and residence time for development of cementation strength of minus 0.5-inch Green River oil shale are direct mode at 1,510° F and 2.0 hours or indirect mode at 1,530° F and 2.9 hours. Maximum obtained compressive strengths developed during moist curing were 270 and 326 psi, respectively. Use of a differential oil shale retort allowed close control and measurement of the retorting conditions. Correlations were developed for compressive strength as a function of curing time at 100° F, for compressive strength as a function of direct mode retorting temperature and time, and for compressive strength of indirect mode retorting temperature and time. Other information developed as functions of retorting temperature, time, and mode included optimum Proctor density, optimum Proctor moisture content, effect of compaction water composition (tapwater versus oil shale retort water), leachate composition from the retorted shale, and permeability of compacted but uncured retorted shale. The retorted shale apparently acted as an effective filter for many of the ions in the retort water. A petrographic analysis including optical microscopy, scanning electron microscopy, X-ray diffraction, and X-ray fluorescence indicated that the cementing mechanism is the interlocking growth of acicular crystals on the surface of the retorted shale fragments. The crystals appear to be composed of a hydrated calcium aluminum sulfate. Research done under Contract No. J0285001 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., 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 80–179138; paper copy price code A07.

OFR 55–80. Analysis of Industry Research and Development Recommendations in Mining and Reclamation Technology, by Science Management Corp. Aug. 7, 1979. 168 pp. Recommendations from 44 mining industry workshops are summarized and reviewed in the context of Bureau of Mines research and development programs during 1974–77. Approximately 1,000 specific recommendations for research and development are summarized in a systematic and comprehensive format appropriate for review by mining research and development program managers. Relevant Bureau research programs are briefly described and some opportunities for future research and development are identified. Research done under Contract No. J0188063. 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., 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. Copies of this report will not be available for purchase.

OFR 56–80. Characterization of Respirable Coal Mine Dust by Computer Analysis of Scanning Electron Microscope Images, by G. G. Johnson, Jr., and E. W. White. July 1, 1979. 79 pp. 16 figs. The use of the scanning electron microscope (SEM) to characterize coal mine dust has been possible because of two circumstances. First, the imaging process of the SEM allows multiple signals (secondary and backscattered electrons, X-ray emission, etc.) to be viewed. Second, the use of a computer to analyze the signals and perform statistical tests on the results. The parameters described are size, shape, chemical composition, mass distributions, and particle thickness. Although the system is intended for particular systems, those of agglomerates are handled by special aspects of the computer programs. Research done under Grant No. G0101720 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., and Morgantown, W. Va.; National Health and Safety Academy, Beckley, W. Va.; 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 57–80. Geophysical Techniques Applied to Oil Shale Mining Operations, by P. Jackson, H. Bennett, A. Liskow, R. Shuchman, R. Turpening, and L. Wilock. February 1978. 251 pp. 34 figs. To investigate the use of integrated geophysics for the placement of oil shale mines, data were gathered during four field trips to two test sites in the Piceance Creek Basin, Colo. Seismic, resistivity, audiomagnetotellurics (AMT), induced polarization (IP) gravity, and magnetic data were gathered. Available remote sensing data were used for reconnaissance. Landstat data indicated a linear zone that alined with faults found in both test sites. The faults, one of which was confirmed by an observation well, were indicated by resistivity, AMT, and closely spaced seismic arrays. With remote sensing for reconnaissance, resistivity or AMT, and then closely spaced seismic array are the sequence of geophysical measurements that should be undertaken in this region. For analysis of integrated geophysical data, interactive computer modeling was developed in which seismics, gravity, and resistivity data can be simultaneously simulated. Re-

search done under Contract No. H0252062 by the Environmental Research Institute 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.; 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. Copies of this report will not be available for purchase.

OFR 58–80. Oil Shale Mining Environmental Research Program Overview, by C. Ogasawara, G. F. Kuncir, and D. A. Lewis. June 1979. 64 pp. 14 figs. This report describes the direction and progress of the Bureau of Mines Oil Shale Mining Environmental Research Program as of January 31, 1979. The report focuses on the Bureau's role in environmental research supporting oil shale development with respect to the activities of other involved Government agencies and private industry. Environmental considerations in oil shale extraction, such as ecological disturbances, health and safety hazards, waste management, and socioeconomic impacts, are discussed along with the type of research known to be planned by organizations to ameliorate these problems. Research done under Contract No. 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., 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 80–179112; paper copy price code A04.

OFR 59–80. Mine Materials Handling Vehicle (MMHV), by A. L. Foote and J. S. Schaefer. Aug. 18, 1978. 308 pp. 95 figs. The purpose of this investigation was to develop a mechanical device that could safely perform handling tasks that are normally done manually in underground bituminous coal mines. The report discusses studies leading to construction of a battery-operated, three-wheel vehicle with a 6° of freedom manipulator. Supportive design studies included collection and analysis of production, manual functions, and injury data on the underground bituminous coal mining industry. Transfer tasks in section storage and working places were the prime candidates for mechanical handling. Functional specifications were developed for two handling devices (one to handle existing unit loads and one to handle repackaged unit loads) and for a vehicle to mount the handling device. Design concepts for nine different handling devices were developed and a cost-benefit evaluation was made for each. Detail design, capital and operating costs, and method improvement savings data were developed for two battery-operated vehicles and for two different manipulators. The three-wheel vehicle with anthropomorphic manipulator was chosen for development. Research done under Contract No. H0242015 by MBAssociates. 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., 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 80–178890; paper copy price code A14.

OFR 60(1)–80. A Program Plan for Determining Optimum Roof Bolt Tension. Theory and Application of Rock Reinforcement in Coal Mines. Volume 1 of 2, by T. A. Lang, J. A. Bischoff and P. L. Wagner. March 1979. 257 pp. 82 figs. The objective of this investigation was to develop a program plan of analytical studies and tests to determine (1) the optimum installation tension of a coal mine roof bolt, (2) the most valid bolt support theory or theories, and (3) the most valid roof failure theory or theories. On this basis, a comprehensive literature search was made and significant material dealing with coal mine behavior, roof bolting, and roof support was collected, reviewed, classified, and analyzed. Emphasis was given to the influence of rock reinforcement on the control of deformation, stress field modification, and mine roof stability. An assessment was made of the effect of various parameters including bolt tension, bolt pattern, and time of installation on the effectiveness of rock reinforcement systems, and equations were developed for bolt tension as a function of these parameters and rock properties. From these studies, a major program plan of tests and studies was developed to verify and validate the most tenable theories of roof behavior and roof support and to determine optimum bolt installation tension. Research done under Contract No. J0285006 by Leeds, Hill and Jewett, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., 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 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 80–179195; paper copy price code A12.

OFR 60(2)–80. A Program Plan for Determining Optimum Roof Bolt Tension. Theory and Application of Rock Reinforcement Systems in Coal Mines. Volume 2 of 2 (General Bibliography), by T. A. Lang, J. A. Bischoff, and P. L. Wagner. March 1979. 43 pp. The objective of this investigation was to develop a program plan of analytical studies and tests to determine (1) the optimum installation tension of a coal mine roof bolt, (2) the most valid bolt support theory or theories, and (3) the most valid roof failure theory or theories. Volume 2 comprises the bibliography. Research done under Contract No. J0285006 by Leeds, Hill and Jewett, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., 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 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 80–179187; paper copy price code A03.

OFR 61–80. Deep Cutting Miner Production Tests, by Mukund D. Gangal and Bani R. Banerjee. April 1979. 86 pp. 20 figs. A deep-cutting continuous miner was tested under production-mining

conditions at the Joanne mine, Rachel, W. Va., for about 1–1/2 years (226 production days). The miner was run in a low-head revolution per minute, deep-cutting mode and a high revolution per minute, shallow-cutting mode. The tests confirmed that deep cutting and slow cutter speed reduce respirable dust significantly under production-mining conditions. Quantitative reductions in dust, in deep versus shallow cutting, were 73 percent in return air and 63 percent at the operator's location. Production rate (tons per shift) and bit consumption rate did not show any relationship to deep or shallow cutting. Reliability and maintainability of the miner were worse in deep-cutting mode because of cutter drive shaft failures; the cutter shaft problem was solved through improved material and design. Except for cutter shaft repairs, maintainability was similar for deep and shallow cutting. Research done under Contract No. J0177019 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., 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 80–183932; paper copy price code A05.

OFR 62–80. Development of a Rapid Response Radon Monitor, by Richard I. Miller. Nov. 15, 1979. 69 pp. 15 figs. A rapid response radon monitor capable of accurately responding within 3 min to changing radon levels of magnitude from 100 to 10,000 pCi/l (typical of the levels in working uranium mines) was developed for the Bureau of Mines. The 12- by 10- by 6-inch instrument weighs 17 lb and is capable of 8 hours of continuous portable operation with a self-contained, rechargeable battery power source. Residual chamber contamination from a radon level allowed to remain in the chamber for 90 min is about 10 pct, decaying about a factor of 2 in 1 hour. The instrument sensitivity is a nominal 0.1 cpm (pCi/l), with a background count rate of less than 1 cpm. Research done under Contract No. H0262019 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., 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 80–183924; paper copy price code A04.

OFR 63–80. State-of-the-Art of Sampling and Analysis for Diesel Exhaust Contaminants, by K. T. Menzies, P. L. Levins, M. G. Broome, and M. H. Fanucci. July 30, 1979. 174 pp. 19 figs. Over 1,500 literature citations related to diesel exhaust sampling and analysis were obtained as a result of computer and manual searches of 9 data bases. Abstracts and hard copies of relevant citations were reviewed and those considered appropriate for evaluation were included in a bibliography. Based on the literature collected, available sampling and analysis methods for the following diesel exhaust contaminants were evaluated: CO, CO_2, NO, NO_2, hydrocarbons, particulates, PNA, SO_4, and oxygenates. Emphasis was given to laboratory and field methods for these species. Methods were evaluated on the basis of sensitivity, selectivity, accuracy, and reliability and a selected list of preferred methods was developed for each compound class. The selected methods were additionally evaluated through communication with current investigators. Sampling and analysis methods for all compounds except CO and CO_2 showed some unreliability. Recommendations were made for future research to develop, improve, and validate methods. Research done under Contract No. J0387208 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., 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 80–183353; paper copy price code A08.

OFR 64–80. Development of a Reliable Method for Evaluation of Deep Sea Manganese Nodule Deposits, by R. H. Fewkes, W. D. McFarland, W. R. Reinhart, and R. K. Sorem. Jan. 12, 1979. 94 pp. 9 figs. Methods of estimating manganese nodule grade and concentration were investigated using data from a well-explored east-central Pacific manganese nodule deposit. Bulk chemical analyses of 159 nodules recovered from 21 box cores show that the range in metal values between nodules from a single box core is commonly small but may be greater than the range in mean metal content of nodules from widely separated box cores. The metal exhibiting the greatest variability in the 21 box cores is Zn, followed in decreasing order by Cu, Mn, Co, Ni, and Fe. Approximately half of the box cores required analyses of 11 nodules or more to predict metal content within ± 10 percent of the mean value. Research done under Grant No. G0274013 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 80–182116; paper copy price code A05.

OFR 65–80. Hoist Rope Lubrication Criteria, by Richard L. Jentgen. July 1978. 209 pp. 19 figs. The objective of this report was to search and organize world literature and industry practices connected with lubricants and lubricant-application techniques for wire ropes used in underground mine hoists. A secondary objective included the development of a rationale for selection of hoist-rope lubricants. Actual experiences in mines were concluded to offer a variety of lubricants and techniques that could be emulated by others in an effort to achieve improved hoist-rope reliability and life. When most of these lubricants were evaluated in the laboratory, it was found that they ranked highest in the majority of tests related to function. This led to the recommendation that low-viscosity oil-type lubricants are the materials of choice with which to maintain hoist ropes. A prototype specification covering the recommended lubricants was formed. The report contains conclusions and detailed recommendations resulting from each task including suggestions for needed research. Research done under Contract No. J0377011 by Battelle Columbus Laboratories. 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., 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 80–182959; paper copy price code A10.

OFR 66–80. Tiltmeter Data Analysis Windpipe Project, White Pine, by C. G. Kirkpatrick. July 13, 1979. 45 pp. 19 figs. Analysis of the data produced by a wide-band, sensitive, horizontal, biaxial motion sensor revealed several distinctive patterns before, during, and after a roof fall. The signals prior to the roof fall are similar in spectra, but 1,000 times larger in amplitude, than those after the roof fall. Immediately preceding the roof fall, by 2 to 12 hours, five events occurred that were larger in amplitude and lower in frequency than even the large preroof fall background signals. An interpretation of these events is presented. Research done under Contract No. J0285007 by Rockwell International. 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., 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 80–190572; paper copy price code A03.

OFR 67–80. Identify and Evaluate Lightweight Support Substitutes, by Gilbert L. Forst. Sept. 30, 1978. 63 pp. 13 figs. The objective of this program was to identify and evaluate superior, lightweight substitutes for selected coal mine roof support concepts such as crossbars, posts, and crib blocks. Engineering analysis and concept design identified, through tradeoff studies, that some materials are promising from a technical standpoint, as support substitutes such as E-glass reinforced polyester resin, high-strength low-alloy steel, aluminum, and very high early strength (VHE) cement. An economic analysis indicates that none of the lightweight substitutes are economically competitive with wood on an initial cost basis; however, in terms of life cycle costs based on current dollars, the high-strength, low-alloy steel appears competitive for crossbars, and the VHE cement and E-glass-resin appear competitive for posts. Research done under Contract No. J0275012 by FMC 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., 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 80–190580; paper copy price code A04.

OFR 68–80. Possible Uses of Manganese Dioxide in Ceramic Applications. Literature Review and Analysis, by V. L. Burdick, R. A. Condrate, E. E. Mueller, D. R. Rossington, and D. B. Sass. Feb. 11, 1980. 71 pp. 1 fig. This report presents a literature review of current uses of MnO_2 and suggestions for future research. The historical background, oceanographic distribution, geology, exploitation, law, and politics of MnO_2 are included. Uses of MnO_2 in ferrites, semiconductors, catalytic processes, thermoluminescence, and photochromic materials are presented. A select bibliography of 33 items and 129 references are presented at the end of the report. Research done under Contract No. J0199130 by Alfred 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.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80–192214; paper copy price code A04.

OFR 69–80. Process for Recovering Chromium and Other Metals From Superalloy Scrap, by J. J. deBarbadillo, J. K. Pargeter, and H. V. Makar. Apr. 15, 1980. 156 pp. 31 figs. This report describes a process for recovering chromium and other metals from superalloy scrap. Part I contains the results of laboratory-scale experiments that were conducted to test a complex flowsheet utilizing a wide range of extractive metallurgical operations. The basis for the process is the formation of a sulfide matte in which chromium is concentrated as a discrete chromium sulfide phase. Mineral processing and hydrometallurgical procedures are used to separate chromium sulfide from the other matte constituents. Parf II encompasses a preliminary engineering design of a pilot plant capable of treating 100 pounds of superalloy scrap per hour. Also included is an economic analysis of the operation of the pilot plant. Research done under Contract No. J0188056 by International Nickel Co., 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 70–80. Occurrences and Potential for Lead and Zinc Mineralization in the Mt. Schwatka Region, by James C. Barker. 1980. 51 pp. 3 figs. The Mt. Schwatka region, located about 75 miles north of Fairbanks, was investigated to provide data on mineral potential for the Bureau of Land Management. The investigations were undertaken in early 1978 as a result of a tentative geological correlation of this area to the Selwyn Basin lead-zinc districts, eastern Alaska, and the Yukon Territory. Correlation is based on a reconstruction of approximately 450 km of right-lateral Mesozoic movement along the Tintina Fault system. Prior to the investigation, there was no recorded information concerning mineralization or mining-claim locations. Occurrences of lead and zinc were found in an area underlain by early to mid-Paleozoic marine sediments and volcanics. There appears to be an affinity between these occurrences and the succession of units known as the Fossil Creek volcanics-Ordovicians(Silurian?). In one case, volcanogenic zinc was found in a cherty, intermediate, tuffaceous breccia. Lead and zinc values also appear associated with the upper stratigraphic levels of the volcanics and controlled by the unconformity and/or fault contact with the overlying Tolovana limestone. Manganese mineralization was identified in undifferentiated Paleozoic

(Permian?) cherts and mafic volcanics to the west. There also appears to be a potential for asbestos 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 71–80. Radon Daughter Dosimeter Tests in Active Uranium Mines, by William D. Dodge and Van B. Parr. May 1980. 112 pp. 11 figs. Six underground tests were conducted to evaluate the performance and determine the reliability of three different types of personal radon daughter dosimeter systems in active uranium mine usage. Mean-time-between-failures estimates from 194.4 to 276.2 hours were obtained, and advantages and disadvantages of each system are identified. Test results suggest one system is marginally acceptable for large-scale uranium mining usage. Recommendations are presented for improving the existing systems and for developing new and more satisfactory versions. Research done under Contract No. H0282031 by Southwest Research Institute. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., 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 Morgantown, W. Va.; National Mine Health and Safety Academy, Beckley, W. Va.; Office of Surface Mining Library, South Interior Building, Washington, D.C.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80–203599; paper copy price code A06.

OFR 72–80. Design, Fabrication and Demonstration of an Inert Gas Generator. Volume II. Operations and Maintenance Manual, by Steven K. Ruggieri and and John T. Dieckmann. January 1980. 150 pp. 56 figs. This report describes the operation and maintenance of a mobile inert gas generator for use in a remote sealing system for fighting underground coal mine fires. Seals are emplaced in mine passageways between the fire zone and the rest of the mine isolating the fire zone. The seals consist of fly ash that has been pneumatically conveyed by inert gas through a borehole connecting the surface and the passageway. Inert gas is used as the fly ash seal transport medium (instead of fresh air) since the introduction of large volumes of fresh air in the vicinity of the fire zone would be undesirable. The inert gas generator has been performance tested and operated in the field for approximately 200 hours. The system is currently available for fighting any future underground coal mine fires. Research done under Contract No. H0155053 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., 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 80–207368; paper copy price code A07.

OFR 73–80. Topsoil Rock Removal Technology, by Walter W. Kaufman, Dale N. Reynolds, and John J. Noll. Oct. 31, 1979. 106 pp. 23 figs. This report summarizes a study conducted to determine the state-of-the-art of various rock removal systems and their capabilities. The objective of the study was to determine if currently manufactured equipment can adequately accomplish rock removal in surface mine reclamation applications. Evaluations of State reclamation regulations, with regard to topsoil rock content, were made to determine the rock removal requirements. The major categories of equipment studied are rock pickers and rock rakes. The impact of rock removal implementation on the reclamation operations is discussed in detail. Research done under contract J0285023 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., 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 80–204571; paper copy price code A06.

OFR 74(1)–80. Hazardous Surface Openings to Abandoned Underground Mines, Black Hills National Forest. Volume I: Text, Appendixes A & B, by L. A. Stinnett, M. R. Lawton, and W. F. Jennings. Sept. 28, 1979. 171 pp. 16 figs. This study was conducted to (1) examine a representative sample of surface openings to abandoned and inactive underground mines in the Black Hills, (2) to identify those openings of the sample that are a public hazard, (3) to design low cost protection to eliminate the hazard, and (4) to analyze laws and regulations pertaining to associated hazard elimination and jurisdictional and enforcement problems. Volume I contains the text and appendixes A and B. Research done under Contract No. J0295011 by NUS 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., 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 80–204472; paper copy price code A08.

OFR 74(2)–80. Hazardous Surface Openings to Abandoned Underground Mines, Black Hills National Forest. Volume II: Appendix C. Abandoned Mine Identification Area A, by L. A. Stinnett, M. R. Lawton, and W. F. Jennings. Sept. 28, 1979. 289 pp. This study was conducted to (1) examine a representative sample of surface openings to abandoned and inactive underground mines in the Black Hills, (2) to identify those openings of the sample that are a public hazard, (3) to design low cost protection to eliminate the hazard, and (4) to analyze laws and regulations pertaining to associated hazard elimination and jurisdictional and enforcement problems. Volume II contains appendix C, "Abandoned Mine Identification Area A." Research done under Contract No. J0295011 by NUS 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., 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 80–204480; paper copy price code A13.

OFR 74(3)–80. Hazardous Surface Openings to Abandoned Underground Mines, Black Hills National Forest. Volume III: Appendix C. Abandoned Mine Identification Areas B, C, and D, by L. A. Stinnett, M. R. Lawton, and W. F. Jennings. Sept. 28, 1979. 389 pp. This study was conducted to (1) examine a representative sample of surface openings to abandoned and inactive underground mines in the Black Hills, (2) to identify those openings of the sample that are a public hazard, (3) to design low cost protection to eliminate the hazard, and (4) to analyze laws and regulations pertaining to associated hazard elimination and jurisdictional and enforcement problems. Volume III contains appendix C, "Abandoned Mine Identification Areas B, C, and D." Research done under Contract No. J0295011 by NUS 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., 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 80–204498; paper copy price code A17.

OFR 75–80. Pyrometallurgical Recovery of Chromium From Scrap Metals: Laboratory Studies and Pilot Plant Design, by Charles L. Kusik, Krishna Parameswaran, David J. Kinneberg, and Harry V. Makar. February 1980. 68 pp. 13 figs. The objective of this investigation was to experimentally determine the feasibility of recovering chromium from critical scrap metals containing significant quantities of this element. Based on a conceptual chromium recovery flowsheet, the 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. Descriptive material and cost estimates are developed for a pilot plant to demonstrate the process. Research done under Contract No. J0188170 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., Reno, Nev., Albany, Oreg., Pittsburgh, Pa., Salt Lake City, Utah, and Spokane, Wash.; and at the 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 76–80. The Application of Advanced Mine Air Monitoring Techniques to Mines Using Diesel Powered Equipment, by John H. Johnson, David H. Carlson, and Edward O. Reinbold. July 31, 1979. 191 pp. 116 figs. Stratification of exhaust from a load haul dump was studied in an 80-foot-long dead end heading located in the White Pine Mine section designated for exhaust emissions studies. The mine air monitoring laboratory was used to gather temperature and CO_2 concentration data at 10 locations. The data substantiate the presence of strong buoyant forces of the hot exhaust gases that result in stratification in dead end headings. Diesel mine-vehicle emissions were monitored in the laboratory by a portable tailpipe emissions measurement apparatus assembled for in-mine use. The results were compared with simultaneous measurements by standard laboratory exhaust monitoring instruments. These results indicate that accurate field source quality control measurements can be obtained for CO_2, CO, and NO but NO_2 results were low for all engine conditions. Diesel pollutant concentration data from the Orchard Valley Mine were analyzed and compared with data collected earlier in the White Pine and Brushy Creek Mines. Lognormal frequency distributions and CO_2-based concentration ratios and correlations were calculated. In the three mines compared, pollutant concentrations were distributed similarly, and concentrations appear to be controlled to present standards. Research done under Grant No. G0166027 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. Order ONLY from NTIS: PB 80–207541; paper copy price code A09.

OFR 77–80. Development of a Deep Penetrating Borehole Geophysical Technique for Predicting Hazards Ahead of Coal Mining, by Sidney A. Suhler, Thomas E. Owen, Jackie E. Hipp, and Wendell R. Peters. July 5, 1978. 124 pp. 29 figs. A field operable, breadboard model, borehole radar was developed to detect hazardous geological anomalies in and above a coal seam in advance of mining. A 4-inch-diameter downhole probe was fabricated and tested in several environments. The radar transmitter was also employed in a cross-hole or through-transmission mode to determine natural geotechnical and manufactured conditions between boreholes. Sensitivity to underground conditions in both modes of operation were indicated. Research done under contract H0252033 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., 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 80–208614; paper copy price code A06.

OFR 78(1)–80. Surface Mine Spoil Stability Evaluation, Interior Coal Province. Volume I—Main Report. Glossary of Terms (Appendix A) & Annotated Bibliography (Appendix B), by Raymond P. Miller, Peter M. Douglass, Robert A. Robinson, David A. Roberts, and William T. Laprade. August 1979. 330 pp. 83 figs. This two-volume report addresses slope stability of surface mine spoils within the interior coal province. Sixteen mines were visited, pertinent data and samples were collected, and re-

ported spoil instabilities were back-analyzed. Laboratory test results are compared to back-analyzed material properties. Available methods of slope stability analysis are reviewed and evaluated with respect to application to mine spoil stability evaluation and prediction. Correlation and tentative relationships among spoil material properties, highwall conditions, mining equipment and procedures, and empirical observations are presented. Slope stability sensitivity plots illustrate the relative significance of various input parameters on stability. Slope stability input parameters are correlated with site and mining conditions to identify the primary factors controlling spoil stability. Investigative methods, spoil stability enhancement techniques, spoil stability prediction procedures, and future study areas are discussed. Appendixes include a glossary of terms, an annotated bibliography, details of mine visits, and detailed laboratory test procedures and results. Research done under Contract No. J0275013 by Shannon & Wilson, 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., 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 80–211113; paper copy price code A15.

OFR 78(2)–80. Surface Mine Spoil Stability Evaluation, Interior Coal Province, Volume II—Details of Mine Visits & Detailed Procedures of Laboratory Testing (Appendix C), by Raymond P. Miller, Peter M. Douglass, Robert A. Robinson, David A. Roberts, and William T. Laprade. August 1979. 398 pp. 263 figs. This two-volume report addresses slope stability of surface mine spoils within the interior coal province. Volume II presents detailed discussions of the individual mine visits and laboratory testing procedures and results, the general approach to the mine visits, and the various methods used to obtain information at the surface mines. Research done under Contract No. J0275013 by Shannon & Wilson, 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., 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 80–211121; paper copy price code A17.

OFR 79–80. Improved Spontaneous Combustion Protection for Underground Metal Mines, by Ralph B. Stevens. November 1979. 262 pp. 66 figs. The objective of this 20-month program was to define the relationships between mine ventilation, temperature, humidity, ore properties, materials used in mine operations, etc., and the spontaneous combustion problem in underground metal mines. Tradeoff studies availability, reliability, cost, and maintenance of spontaneous combustion protection sensors and telemetry were conducted, after which a prototype system was selected from four design alternatives. This selected system was then laboratory tested and demonstrated in an underground copper mine. Research done under Contract No. H0282002 by FMC 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 80–210461; paper copy price code A12.

OFR 80–80. Splice Testing Using a Figure-S Machine and a New Shuttle Car Simulation, by J. Tomlinson, T. Rusnak, R. King, and L. Morley. July 31, 1979. 44 pp. Shuttle car trailing cable splices were tested for resistance to failure upon being subjected to repeated bending, abrasion, and tensile shocks using a new testing method that closely simulates shuttle car induced stress. The results show that under normal stress, splices can be made to withstand the equivalent of 3 months of operational use. Restoring the tensile strength to the conductors is as critical as restoring flexibility. Splices in which the conductors are of slightly unequal length did not present as serious a workmanshop problem as previously thought since test results show that the conductors tend to equalize when longer cables, in contrast to short cables employed in previous testing methods, were used. Dynamic recordings of cable tensile stresses are presented for a shuttle car and the new simulated testing method. Two simple but effective methods for removing insulation using a knife and a pair of pliers are described. None of the designs tested for a sacrificial splice covering were satisfactory. Research done under Grant No. G0188036 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 80–210222; paper copy price code A03.

OFR 81–80. Trailing Cables and Splices: Shielded Cables, by Robert H. King, Barry L. Fisher, and Lloyd A. Morley. Feb. 29, 1980. 69 pp. 16 figs. An analysis of low-voltage shielded trailing cables is performed to develop a method to calculate the differences in operating costs between shielded and nonshielded cables. Two types of shield construction are considered for the three major underground coal mining methods. Data from laboratory and in-mine tests are presented along with an analysis of safety benefits. Recommendations for further investigations include cost impact considerations. Research done under Grant No. G0188036 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., 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 80–208135; paper copy price code A04.

OFR 82–80. Investigation of Shank Tension in Mine Roof Bolts, by R. K. Swanson and G. L. Burkhardt. May 1979. 29 pp. 12 figs. Samples of ⅝- by 60-inch mine roof bolts were measured under test loads by stress measurement instruments, one a magnetic system and the other an ultrasonic birefringence system. Both were designed to detect shank tensile stress by measurement of the induced compressive stress in the head of loaded, generally higher quality bridge bolts. Results of measurements made on the heads of roof bolts indicate that variations in dimensions and other head variables preclude accurate load determination on a random population of installed bolts by either method. However, the ultrasonic system offers a good prospect for recording a reference value from a specific bolt at the time of installation to be used as a basis for subsequent inspection through the life of the structure. Qualitatively, the ultrasonic system would also permit the determination of whether or not a bolt is nominally loaded. Use of a separate "stress washer," installed under the head of the bolt, would permit accurate measurement of the translated stress to provide post-installation inspection with good accuracy using either instrumentation system. The stress washer would be no more than a reasonably accurate steel collar within which a uniform stress would be developed from the loaded bolt. Research done under Contract No. H0292012 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., 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 80–210016; paper copy price code A03.

OFR 83–80. Modelling and Data Analysis of 50 to 5000 kHz Radio Wave Propagation in Coal Mines. Technical Services for Mine Communications Research, by Robert L. Lagace, Alfred G. Emslie, and Michael A. Grossman. February 1980. 109 pp. 66 figs. The objective of this work was to formulate simple theoretical models characterizing medium frequency (MF) radio wave propagation in underground room-and-pillar coal mines to predict the most favorable operating frequencies and maximum communication ranges for portable radios carried by key miners. This was achieved and confirmed experimentally for conductor-free areas of coal mines. In areas where a conductor such as a power cable is present, applicable data must yet be taken before the propagation model can be confirmed. This report describes the theoretical models developed for MF radio propagation in coal mines, compares theoretical results with experimental measurements made in a large number of mines located in various coal seams, and summarizes the findings and their implications for portable radio communications between roving miners. Research done under Contract No. H0346045 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 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 80–209455; paper copy price code A06.

OFR 84–80. Alternatives for Technology Transfer to the Enterprise, by P. B. Grote, W. A. Coleman, and G. M. Guard. July 1980. 121 pp. 15 figs. This report provides a general description of deep ocean mining (DOM) technology, sources for DOM technology, and identifies approaches and requirements for acquisition by the Enterprise, the organ of the authority that will carry out ocean mining activities, of DOM technology by conventional means. The approaches identified assume the Enterprise enters into a contractual-joint venture arrangements with an uncommitted and competent systems management firm at various stages of the DOM system acquisition process. The approaches provide for training through work-study as well as through direct participation in acquisition programs. The potential success of the alternatives are evaluated in terms of the likelihood of the acquisition of an ongoing Enterprise economic DOM operational capability. The study concludes that sources exist and that the Enterprise should undertake the development of its own technical capability through conceptual design prior to selecting its source for systems management expertise. Research done under Contract No. J0100037 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 80–209497; paper copy price code A06.

OFR 85–80. Evaluation of Selected Factors Impacting on the International Competitiveness of the U.S. Minerals Industry, by Spencer M. Beresford and Henry G. Edler. Nov. 13, 1978. 255 pp. 22 figs. This report compares U.S. and foreign water usage costs; internal transportation costs; antitrust policies, laws, and regulations; and environmental, health, and safety laws and regulations. The analysis is limited to 12 nonfuel minerals and to countries designated by the Bureau of Mines for which substantial data were found. Interviews that were held with representatives of nine companies were discussed. Research done under Contract No. J0188163 by International Technical Services, Inc. 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 86–80. Potential Applications of Drill-Split Fragmentation Systems in Underground Mines, by Michael Kaplan and Dave Chazin. Aug. 20, 1979. 188 pp. 60 figs. An investigation was conducted on the use of a mechanical rock splitter as the primary means for rock fragmentation in underground hard rock mining systems. Analyses and scale model tests

showed that reasonably sized splitters that could be mounted on the booms of conventional drill jumbos were capable of fragmenting over 1 ton of rock per cycle. Detailed drill-split mining systems were developed for entry development, room-and-pillar, bench mining, and cut and fill mining. Economic analyses of these systems showed them to be generally competitive with conventional drill-blast methods. Except for bench mining, drill-split offered substantial cost savings over drill-blast. The investigation also included a technical evaluation of the mechanical splitter, an analysis of health and safety, and a determination of the potential applicability of drilling and splitting. Research done under Contract No. J0285016 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., 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 80–210792; paper copy price code A09.

OFR 87–80. A Technical Basis for the Development of Deep Ocean Mining Regulations, by Philip B. Grote and Wendell Gayman. Sept. 14, 1979. 310 pp. 33 figs. The deep ocean mining industry is in a precommercialization stage of development. In the context of a proper legal-regulatory regime, deep ocean mining system design, site survey, and operation technologies are capable of rapid evolution. This report recommends that the regulatory framework develop in parallel with the industry and presents a rationale to implement this approach. The Government has several interests in deep ocean mining technology: (1) as a potential regulator, sound regulations should be based on an understanding of the technology; (2) as a potential monitor, survey technologies are relevant; and (3) as an estimator of strategic mineral supplies, it is important to understand the technology that allows economic access to deep ocean minerals. Thus, the major portion of the report presents an in-depth review of systems design, operations, and survey equipment and techniques. Research done under Contract No. J0177131 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 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 88–80. Research on the Hydrology and Water Quality of Watersheds Subjected to Surface Mining. Phase 1: Premining Hydrologic and Water Quality Conditions, by U.S. Department of Agriculture. July 1978. 347 pp. 95 figs. Five watersheds, ranging from 29 to 49 acres, were instrumented in east-central Ohio to investigate the hydrologic and water quality conditions occurring before, during, and after surface mining. Physical information was obtained for each watershed, and instrumentation was installed to obtain hydrologic and weather data and water quality samples. Premining ground water systems for each watershed had two major perched aquifers within the top 250 feet. Shallowest ground water is commonly of the calcium bicarbonate type; whereas, water in the deeper aquifers is of variable type. Although dissolved-solids concentration is generally 200 to 600 mg/l, brackish or salty water is present in several areas. A one-dimensional unsaturated flow model was developed to interface with a quasi-three-dimensional ground water model as part of a composite hydrologic model. The unsaturated flow model includes provisions for an evapotranspiration model. Research done under contracts J0166054 and J0166055. 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. Copies of this report will not be available for purchase.

OFR 89–80. Geologic and Engineering Data Acquisition for Underground Coal Mine Ground Control, by David R. Alison, Edvard T. Ohlsson, and Kevin V. Whitney. January 1980. 100 pp. 10 figs. This study was conducted using field interview methods to determine the data and information requirements of the underground coal mining industry to improve mine ground control procedures in existing and future mines. The establishment of a central geologic and engineering information resource center with computer searchable abstract files that can locate and supply descriptive and case-study literature addressing specific mining problems is recommended. A bibliography of underground coal mine ground control literature is included. Research done under Contract No. J0395010 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 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 80–219272; paper copy price code A05.

OFR 90–80. Factory Integration of an Illumination System Into a Continuous Mining Machine, by Bruce Rock. Oct. 29, 1979. 75 pp. 35 figs. A continuous-mining machine was redesigned for the installation of an integrated illumination system. The illumination system was designed by first calculating the theoretical number of luminaires required to meet the Federal illumination standards. Luminaires initially were placed using isointensity diagrams. A darkroom was used for "fine tuning" and demonstrating that the system met the illumination requirements. The luminaire mounts were installed on a machine underground. The performance of the illumination system was monitored in the working environment of an operating coal mine, and design changes were made as necessary during the evaluation period to improve the system. Research done under Contract No. H0366066 by National Mine Service 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 80-219496; paper copy price code A04.

OFR 91-80. Chromium Conservation in Leather Tanning, by Jean J. Tancous, Roger G. Bellingham, Waldo E. Kallenberger, and Alex E. McDonell. Dec. 17, 1979. 194 pp. 7 figs. Currently almost half of the chromium consumed by the U.S. tanning industry is being deposited at landfill sites. In 1978, this amounted to 27,300 tons of dichromate. The research presented in this report consisted of bench-scale tests directed towards ways to increase the usage of this wasted chromium. The report discusses the advantages and disadvantages of the methods tested for recovering chromium from leather scraps, tannery wastewater, and wastewater sludge. Research done under Contract No. H0272026 by Tanners' Council of America, 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 80-222540; paper copy price code A09.

OFR 92-80. Flammability Evaluation of Noise Control Products for Use in Underground Coal Mines, by R. S. Norman, R. A. Hedeen, J. W. Kopec, and T. E. Waterman. June 1979. 95 pp. 117 figs. Noise control programs have been initiated on several types of mining equipment and vehicles that can be used in underground coal mines. The materials that are used in these programs have not been tested for flammability properties. The objective of this program was to select approximately 100 acoustic materials for flammability evaluation. A variety of materials were selected for measurement according to ASTM E-162 procedures. A radiant heat energy source was used to measure flammability properties of 15.2- by 45.7-cm samples. In the absorptive materials category, 45 percent of the materials tested had a flame spread index of less than 25. For barrier, damping, and isolation materials the corresponding values were 40, 43, and 9 percent. Research done under Contract No. J0177039 by IIT 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 81-101990; paper copy price code A05.

OFR 93-80. Effects of Subsidence From Thick Seam Coal Mining on Hydrology, by Richard C. Moore and Michael A. Nawrocki. Mar. 7, 1980. 245 pp. 59 figs. The Bureau of Mines contracted a study to estimate what effects the underground mining of thick coal seams in the Western United States would have on the surrounding water resources. Potential coal fields where this type of mining might occur were identified. Foreign literature was searched for studies of effects on hydrology from thick seam underground coal mining. Based on limited information obtained from the literature, estimates of the effects of this type of mining on the ground and surface water in the Western States were made. Research done under Contract No. J0295012 by Hittman 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., 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 80-219280; paper copy price code A11.

OFR 94-80. Containment Pond Technology. State-of-the-Art, by Vulli L. Gupta and Maurice J. Miles. December 1979. 74 pp. Ponds totaling more than 71,228 acres and within about 500 miles of Boulder City, Nev., were visited or otherwise investigated. This study was expected to indicate needed research relative to pond sealing to contain specific effluents and to conduct a systematic literature survey to assemble and summarize the state-of-the-art related to ponds for containment, treatment, and disposal of industrial effluents. A limited field survey of existing pond installations was also conducted to obtain data on some of the inherent problems and adopted strategies for solutions of such problems. Research done under Contract No. S0271043 by University of Nevada. 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 80-223175; paper copy price code A04.

OFR 95(1)-80. Study of Deep Ocean Mining Operational Economics. Vol. I. Simulation Development and Study of Obstacle Effects, by David R. Peterson and Philip B. Grote. September 1979. 58 pp. 22 figs. This report presents a deep ocean mining operational simulation that is capable of describing the response of the bottom collection unit to specified mining ship maneuvers and the corresponding operation of the mining ship maneuvering system. Bathymetry, obstacles, collector and pipe dynamics, and ship maneuvering capabilities are included in the simulation. The simulation is capable of evaluating the technical requirements and operating costs for specified mine plans. Results are useful in assessing mine size requirements and provide operating cost estimates useful as inputs to deep ocean mining economic feasibility assessments. The simulation is used to determine the consequence of obstacles to mining system operations in terms of impact on mine size requirements and reduced production arising from obstacle avoidance maneuvers of a towed

(unsteered) collector. Research done under Contract No. J0177131 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 National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-219470; paper copy price code A04.

OFR 95(2)-80. Study of Deep Ocean Mining Operational Economics. Vol. II. Deep Ocean Mining Operational Simulation (DOMOPS) User's Manual, by David R. Peterson and Philip B. Grote. September 1979. 56 pp. 4 figs. This report covers five computer codes that were generated during development of a simulation of deep ocean mining operational economics. In addition to a thorough description of each code, internal documentation is provided throughout each, except for the very simple codes, for ease of understanding or possible modification. Research done under Contract No. J0177131 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 National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-219488; paper copy price code A04.

OFR 96(1)-80. Engineering Study of Structural Geologic Features of the Herrin (No. 6) Coal and Associated Rock in Illinois. Volume 1—Summary Report, by H.-F. Krausse, H. H. Damberger, W. J. Nelson, S. R. Hunt, C. T Ledvina, C. G. Treworgy, and W. A. White, with contributions by V. D. Brandow, H. M. Karara, and A. S. Nieto. June 1979. 67 pp. 48 figs. The objectives of this study were to find and describe geologic factors that influence roof conditions in underground mines. The primary method of study was detailed mapping in mines, supplemented by regional computer mapping using drill-hole data, close-range photogrammetry, physical testing of core samples, and clay mineralogical investigations of roof material. Over a period of 3 years, a large volume of data has been generated. The results are reported in two volumes. Volume 1 is a summary for general use of the major findings and conclusions; volume 2 includes a detailed account of the method of study, the data gathered, and the conclusions reached. Research done under Contract No. H0242017 by Illinois State Geological Survey and 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 National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-219454; paper copy price code A04.

OFR 96(2)-80. Engineering Study of Structural Geologic Features of the Herrin (No. 6) Coal and Associated Rock in Illinois. Volume 2—Detailed Report, by H.-F. Krausse, H. H. Damberger, W. J. Nelson, S. R. Hunt, C. T. Ledvina, C. G. Treworgy, and W. A. White, with contributions by V. D. Brandow, H. M. Karara, and A. S. Nieto. June 1979. 218 pp. 179 figs. This report summarizes the status of knowledge on the influence of the geologic and structural fabric of roof strata on roof stability in underground mines in the Herrin No. 6 coal member. The report is based on past investigations and on information collected during recent visits to active mines. The objectives of this study were (1) to identify and describe geologic conditions that influence roof stability, (2) to relate roof performance to the geologic structure by detailed study within selected mines, (3) to present information on areal distribution of comparable geologic conditions that influence roof stability, (4) to compile from literature and files geotechnical data that pertain to roof stability, (5) to collect samples from study areas by diamond drilling, (6) to show how to recognize, both in mines and in diamond drill cores, the various geologic features that influence roof stability, and (7) to propose areas of future research on the subject. Research done under Contract No. H0242017 by Illinois State Geological Survey and 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 National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80-219462; paper copy price code A10.

OFR 97(1)-80. The Effects of Underground Environment and Loading Conditions on Noise Levels of Coal Mining Equipment. Final Report—Volume I, by Ervin P. Fuchs. March 1979. 230 pp. 50 figs. This report presents an evaluation of the acoustic imaging technique to determine the effect of underground environment on the sound pressure level of coal mining equipment. The equipment includes continuous miners, cutting machines, coal drills, loading machines, shuttle cars, roof bolters, and locomotives. The report presents the procedure for obtaining the aboveground and underground measurements, an analysis of noise sources, an assessment of the acoustic imaging technique, and the effect of loading on sound pressure levels. The acoustic imaging technique involves obtaining a value by adding the energy level of the direct sound wave and the energy levels of the reflected sound waves due to tunnel surface for a given source. The obtained value represents the theoretical increase in sound pressure level due to the underground environment. The appendixes provide detailed calculations concerning the evaluation of machine measurements and definitions of terms. The report concludes that the acoustic imaging technique appears to give good predictions of noise level increases due to the underground environment. Research done under Contract No. J0366030 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. Depart-

ment 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 80–227606; paper copy price code A11.

OFR 97(2)–80. The Effects of Underground Environment and Loading Conditions on Noise Levels of Coal Mining Equipment. Final Report—Volume II, by Ervin P. Fuchs. March 1979. 138 pp. 102 figs. This report presents the reduced vibration data from 10 mining machines that were tested to determine the effect of underground environment and loading conditions on acoustic noise levels of coal mining equipment. Vibration measurements were obtained on machine locations where control or sensing electronics may be mounted. The measurements included vibration data in the 20- to 3,500-Hz frequency range. The 10 mining machines include continuous miners, a loading machine, a coal drill, a roof bolter, and a 25-ton locomotive. A list describing the mining machine, geographic, test location, and test date is shown in table 1. The vibration data has been reduced to octave band, 1/3-octave band, and narrow band levels. Research done under Contract No. J0366030 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 80–227614; paper copy price code A07.

OFR 98–80. Concept Study Shuttle Car Cable Reel, by R. J. Gunderman. April 1980. 77 pp. 18 figs. Cable reel systems for shuttle cars were investigated to determine whether an improved system could be identified. Interviews and mine visits were conducted to better define limitations and problems with present systems. Although simple and relatively inexpensive, present cable reel systems are not fully satisfactory. Several concepts for a different technical configuration were formulated and evaluated. An all-electric system using electronic control and external sensors was recommended for further development. Research done under Contract No. J0395012 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 National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80–219371; paper copy price code A05.

OFR 99–80. Uranium-Phosphorus Chemistry and Extraction of Uranium From Uraniferous Phosphorites, by M. Shamsuddin and Milton E. Wadsworth. Mar. 31, 1980. 83 pp. 12 figs. This report consists of a literature search and assessment related to the recovery of uranium from uraniferous phosphorites. It shows the importance of phosphorites as future uranium resources and the favorable cost comparison when recovered as a byproduct in fertilizer production. The needed research is described, including thermodynamic and mineral processing studies. Research done under Contract No. S0291069 by University of Utah. 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.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 80–229008; paper copy price code A05.

OFR 100–80. Portable Crusher for Underground Mining Applications and Design. Phase I—Design, by Harold J. Miller, Edward E. Laughbaum, and William R. Fisher. Aug. 31, 1978. 111 pp. 46 figs. This report summarizes proposals and findings made in conjunction with the newly designed M-44 low-head portable crusher which is believed well capable of meeting the requirements of a "portable, underground, hard rock" machine as previously defined in earlier reports. Data gathered by use of the ¼-scale model of the M-44 have substantiated and verified the concept sufficiently to justify construction of a full-size machine for further testing under actual mine conditions. Research done under Contract No. J0285003 by Eagle Crusher Co., 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., 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 80–227515; paper copy price code A06.

OFR 101–80. Environmental Assessment of In Situ Mining, by Dennis R. Kasper, Harry W. Martin, Larry D. Munsey, Roshan B. Bhappu, and Clement K. Chase. December 1979. 294 pp. 58 figs. This study evaluates selective environmental impacts of two distinct in situ mining techniques. In situ leaching of uranium, porphyry copper, and native copper and in situ borehole slurry mining of uranium, sandstone, and pebble phosphate ores are the techniques and minerals investigated. The potential impacts onsite in the desert southwest (porphyry copper), Michigan (native copper), Texas and Wyoming (uranium), and Florida and North Carolina (phosphate) are discussed. The study emphasizes those impacts that are unique to in situ solution leaching and borehole slurry mining. Impacts that are characteristic of all construction projects in the general geographical areas investigated, such as socioeconomic effects on surrounding communities and site-specific impacts such as rare and endangered species, are beyong the scope of this study. For each of the in situ processes and associated ores investigated, the physical and chemical characteristics of the systems are described, the toxicity of the leaching solutions are presented, and the potential impacts on the environment are developed. Research done under Contract No. J0265022 by PRC Toups. 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 81–106783; paper copy price code A13.

OFR 102–80. Evaluation of the Kloswall Longwall Mining System, by Paul J. Guay. September 1978. 211 pp. 37 figs. This report presents the results of evaluating a longwall mining system specifically designed to extract a very deep web (60 inches or deeper) from a longwall panel. The report includes a productivity and cost analysis comparing the new mining system with a high-capacity conventional longwall operation taking a 30-inch-wide web. The analysis shows the new system will increase annual production 44 percent and decrease cost per ton off the face 21 percent. The report also includes conceptual drawings and specifications for a high-capacity four-drum shearer and a unique shield-type roof support specifically designed for very wide-web operation. The advantages and problems associated with wide-web mining are discussed in general and as they relate specifically to the equipment selected for the new mining system. The study concludes by recommending that surface coal loading tests be conducted as the follow-on work. Research done under Contract No. J0265028 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 80–227622; paper copy price code A10.

OFR 103–80. Mine Wide Test of the WVU Monitoring Concept. Phase II Final Report: Modular Mine Monitoring and Control System by R. S. Nutter, W. R. Voltz, and M. D. Aldridge. Feb. 29, 1980. 273 pp. 106 figs. The results of designing, constructing, and laboratory testing of a modular distributed, microprocessor-based mine monitoring and control system are presented. A standard computer communications protocol was utilized throughout the system. Tests were performed on the utilization of a high-level language for programing mine monitoring and control systems. Laboratory tests were run on a combined air velocity-methane sensor. Research done under Contract No. H0144114 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 80–227648; paper copy price code A12.

OFR 104(1)–80. Selective Placement of Coal Stripmine Overburden in Montana. I. Data Base, by D. J. Dollhopf, W. D. Hall, W. M. Schafer, E. J. DePuit, and R. L. Hodder. June 1977. 116 pp. 19 figs. The specific objective of this 3-year study is to investigate the means of reestablishing non-polluted hydrologic systems in areas where surface mining directly impacts shallow ground water resources. The research area chosen for the study is located near Colstrip, Mont., at a new mine site where chemical analysis of core samples from the overburden suggested that excessive concentrations of several elements would be encountered during the mining process. The report discusses local vegetation, soils, and regional geology and hydrology. Research done under Contract No. H0262032 by Montana State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., 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 81–103186; paper copy price code A06.

OFR 104(2)–80. Selective Placement of Coal Stripmine Overburden in Montana. II. Initial Field Demonstration, by D. J. Dollhopf, W. D. Hall, C. A. Cull, and R. L. Hodder. June 1977. 108 pp. 42 figs. A week-long selective overburden handling dragline operation was conducted at a strip mine near Colstrip, Mont. The objective of the demonstration was to hydrologically isolate a saline overburden zone during placement in the spoil piles. The saline zone had concentrations considered inimical to successful reclamation and was potentially dangerous to future water quality in the spoils aquifer. The zone was identified after review of chemical data for overburden samples collected from the intense 60–m-grid drilling pattern. The saline zone in the overburden was handled in a normal manner; segregated and buried; and segregated, buried, and covered with a relatively impermeable 1.0-m-thick clay cap. The method used to formulate this demonstration, the demonstration itself, and the monitoring and evaluation techniques are described in this report. Research done under Contract No. H0262032 by Montana State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., 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 81–103178; paper copy price code A06.

OFR 104(3)–80. Selective Placement of Coal Stripmine Overburden in Montana. III. Spoil Mixing Phenomena, by D. J. Dollhopf, J. D. Goering, C. J. Levine, B. J. Bauman, D. W. Hedberg, and R. L. Hodder. July 1978. 79 pp. 27 figs. An overburden handling dragline operation was conducted at a strip mine near Colstrip, Mont. The objective of the demonstration was to determine the degree a dragline could mix overburden inhibitory zones dur-

ing the spoiling process. To quantify the mixing process the overburden was scatter spoiled, dump spoiled, and spoiled in a normal manner. This demonstration was part of an effort to investigate means of reestablishing nonpolluted hydrological systems in areas where surface mining directly impacts shallow ground water resources. Research done under Contract No. H0262032 by Montana State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., 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 81–103160; paper copy price code A05.

OFR 104(4)–80. Selective Placement of Coal Strip Mine Overburden in Montana. IV. Hydrogeologic Studies, by D. J. Dollhopf, J. D. Goering, C. J. Levine, B. J. Bauman, and R. L. Hodder. July 1979. 58 pp. 20 figs. The objective of this investigation is to establish nonpolluted hydrological systems in areas where surface mining directly impacts shallow ground water resources. Chemically undesirable overburden material was selectively backfilled with the intent that it would be below the future root zone, be above the reestablished aquifer, and would not be leached as a result of deep percolation. After 2 years the buried material remains above the spoil aquifer and below the maximum rooting depth. Unsaturated water flow from the land surface to the buried material occurred during wet climatological periods. However, no significant leaching of buried material was observed. Research done under Contract No. H0262032 by Montana State University. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Twin Cities, Minn., 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 81–103194; paper copy price code A04.

OFR 105–80. Structure Response and Damage Produced by Ground Vibration From Blasting, by D. E. Siskind, M. S. Stagg, J. W. Kopp, and C. H. Dowding. Aug. 20, 1980. 176 pp. 68 figs. The Bureau of Mines studied blast-produced ground vibration from surface mining to assess its damage and annoyance potential, and to determine safe levels and appropriate measurement techniques. Direct measurements were made of ground-vibration-produced structure responses and damage in 76 homes for 219 production blasts. The results were combined with damage data from nine other blasting studies, including three analyzed previously for Bureau of Mines Bulletin 656. Safe levels of ground vibration from blasting ranged from 0.5 to 2.0 in/sec peak particle velocity for residential-type structures. The damage threshold values are functions of the frequencies of the vibration transmitted into the residences and the types of construction. Particularly serious are the low-frequency vibrations existing in soft foundation materials and/or blast-to-residence distances that not only produce structural resonances, but also excessive levels of displacement and strain. Research done by Twin Cities Research 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.; 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 106–80. Measurement of Mine Room Movement, by Ivor Hawkes. July 1978. 238 pp. 49 figs. This report describes the results of a study of instruments designed to monitor mine roof movements. The theory of such measurements is briefly reviewed and a detailed literature survey and a bibliography are presented. Eight different single and multipoint borehole extensometers that are either novel or improved versions of existing roof movement measurement instruments and permit remote or on-site reading are described in detail together with two novel instruments to monitor mine roof-to-floor convergence. Research done under contract H0366033 by Ivor Hawkes 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 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 107–80. Design and Develop Standardized Controls in Roof Bolting Machines—Preliminary Design, by Terry L. Muldoon, Steven Ruggieri, Thomas Gore, and L. Bruce McDonald. April 1980. 63 pp. 4 figs. This report describes the development of preliminary requirement specifications for standardized operating controls for roof bolting machines used in underground coal mining. Observations of roof bolting operations and discussions with roof bolter manufacturers coupled with detailed analyses of roof bolter control design specifications were performed. Detailed roof bolter operator task analyses, commonality of control analyses, and classical link analyses were also performed. The results were then used to produce preliminary requirement specifications for standardized controls. Research done under Contract No. H0292041 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 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 108–80. Evaluation of Metal Resources at and Near Proposed Deep Sea Mine Sites, by R. H. Fewkes, W. D. McFarland, W. R. Reinhart, and R. K. Sorem. Feb. 15, 1980. 239 pp. 48 figs. The resource potential of three central Pacific manganese nodule deposits is evaluated using sea floor photographs and box core samples. Mean nodule

concentration for the three deposits ranged from a low of 3.8 kg/m² (dry) near DOMES Site B to a high of 7.1 kg/m² (dry) near DOMES Site C. A nodule concentrations of 4.4 kg/m² (dry) was estimated for the area surrounding DOMES Site A. Nodules rich in Mn, Ni, and Cu characterize the Site B area, but low nodule abundance estimates suggest a limited resource potential. Nodule grade is lower and nodule abundance is slightly higher near Site A. The area surrounding Site C appears to have the greatest potential for supplying ocean floor metals. An extensive appendix is included listing metal values for 882 nodules recovered from 144 sample sites. Sample locations and mean metal values for each location are shown on 44 maps. The report also includes an extensive listing of nodule physical characteristics and population data derived from the analysis of sea floor photographs. Research done under Grant No. G0284008 by Washington State University. Available for reference at Bureau of Mines facilities in Denver, Colo., Twin Cities, Minn., 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 80–228992; paper copy price code A11.

OFR 109–80. Estimation and Evaluation of the Iron Ore Reserves of the United States—A Partial Survey 1974–75. Iron Ore Reserves of the Mesabi Range, Minnesota. A Minerals Availability System Report, by Ralph W. Marsden. Jan. 23, 1980. 81 pp. 3 figs. This report is a comprehensive study of the iron ore reserves of the Mesabi Range, Minn. Iron ore has been classified into seven categories with descriptions of each category and the geologic factors affecting each reserve estimate. Iron ore reserves for all classes, grades, and probabilities are based on breakeven analysis and average 1974 dollars. The reserve estimate is reported on a township-range basis. Research done under Contract No. J0188074 by University of Minnesota—Duluth. Available for reference at Bureau of Mines facilities in Denver, Colo., Twin Cities, Minn., 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 80–228984; paper copy price code A05.

OFR 110–80. An Interactive Computer System for Evaluating Coal Mine Illumination, by Robert Goldstein. March 1980. 21 pp. 2 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 the mine entry surfaces for any desired machine-luminaire-entry configuration. 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 No. S0271041 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 81–125528; paper copy price code A02.

OFR 111–80. Rapid Excavation of Rock With Small Charges of High Explosive, by George B. Clark, David W. Ashcom, and Kanaan Hanna. January 1980. 250 pp. 54 figs. The purpose of this investigation was to test a blast shield, develop a conceptual design for an automated drill and blast system (ADBS), and make an economic analysis of the ADBS compared with conventional drill, blast, and muck (DBM) systems. The ADBS tunneling concept was developed in an effort to design an excavation system of greater efficiency than the DBM systems conventionally used. The ADBS would minimize downtime and approach noncyclic efficiently by small charge blasting. Small charge blasting uses simultaneously detonated light charges in four to eight short holes, usually in a line. Limitation of the total explosive per blast reduced air blast overpressure, fly rock velocity, vibrations, and noise enabling the blast shield to adequately contain these side effects. Conceptual design for the ADBS included blast shield, chassis, hydraulic drills, automated explosive loading and firing system, and an armored cab. Horizontal and vertical blast shield alinement controls and ventilation are incorporated into the design. The economic analysis determined ADBS advance costs to be 17 to 20 pct lower than DBM on a per foot basis. Research done under Contract No. H0272020 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.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–125577; paper copy price code A11.

OFR 112–80. Evaluation of Fluorescent Lighting Systems in Various Underground Coal Mines, by A. E. Ketler. May 1979. 110 pp. 71 figs. This report describes a variety of coal mining lighting projects that were funded by the Bureau of Mines to obtain underground lighting experience in support of new lighting requirements for underground coal mines. Some of the variables covered were low and high coal, narrow and wide entries, conventional and continuous mining, ac and dc power, bituminous and anthracite coal, machine mounting, and area lighting. Research done under Contract No. H0252058 by OCENCO, 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 81–125262; paper copy price code A06.

OFR 113–80. Column Leaching of Low-Grade Chalcopyrite Ores Using Thermophilic Bacteria, by Corale L. Brierley. July 1979. 96 pp. 28 figs. Low-grade porphyry copper ores containing chalcopyrite as the primary mineral was leached by two strains

of acidophilic, thermophilic microbes belonging to the genus *Sulfobus*. Leach tests were conducted in glass columns heated to 60° to 70° C. Ores sized to minus ½ inch plus 50 mesh were effectively leached by the thermophilic organisms, but ores sized to minus 2 inch plus ½ inch resisted leaching. Decreasing the pH of the leachate to about 1.8 enhanced the copper extraction from ore with the thermophilic microbes. The bacterium *Thiobacillus ferrooxidans* was relatively ineffective for extracting copper from the ore. Research done under Grant No. G0177100 by New Mexico Bureau of Mines and Mineral Resources, and New Mexico Institute of Mining and Technology. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., Rolla, Mo., Boulder City and 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 81–128498; paper copy price code A05.

OFR 114–80. An Illumination System for a Shortwall Mining Section, by Robert A. Harrow. Sept. 28, 1979. 177 pp. 70 figs. A program to develop, demonstrate, and evaluate a lighting system concept for a working shortwall coal mine section based on the application of lighting system components used in conventional, continuous, and longwall mining sections is described. The objective was achieved by employing an aboveground simulated working place to test and evaluate lighting systems prior to installation underground. The simulator tests were subsequently verified through actual underground tests. Research done under Contract No. H0366065 by General Energy 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 81–128019; paper copy price code A09.

OFR 115–80. Development of Roof Control Techniques for Massive Roof Problems in Longwall Operations, by Peter de Bakker, Andrew Harvey, Michael Cleary, and Timothy Hawkes. November 1979. 191 pp. 51 figs. The objective of this investigation was to design a mechanical roof-breaking device suitable for breaking massive roof and for use with the general range of roof support equipment in longwall operations. Given the state-of-the-art in rock mechanics of the loading requirements to break off massive overhung roof in a longwall operation, two different roof-breaker mechanisms were developed. The most popular roof supports were evaluated for their suitability to be equipped with either of the two mechanisms. The results indicate that the state-of-the-art rock mechanics is not sufficiently advanced to confidently predict roof breakage. Research done under Contract No. H0282045 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 81–125270; paper copy price code A09.

OFR 116–80. Enhancement of Mine Power System Safety and Reliability, by E. K. Stanek. October 1979. 207 pp. 68 figs. This report contains the results of several related research efforts that were aimed at enhancement of mine power system safety and reliability. The largest single effort was on optimum spares and maintenance scheduling for various components of a mine power system. Two closely related tasks involved calculating the minimum arcing faults that could occur on dc trailing cables and the use of trippable load break switches to clear ground faults. Both of these tasks are concerned with reliable fault clearing to prevent shock and fire hazards. Three other closely related tasks were concerned with aspects of mine power system design—alternate network topologies, optimum voltage selection for mine power systems, and selection of system components. The final task consisted of laboratory tests to ascertain the effects of repetitive, low-level transients on insulation systems. Research done under Grant No. G0188097 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 81–125361; paper copy price code A10.

OFR 117–80. Heap Leaching Studies on Uranium Ore. Phase VI: Field-Scale Heap Leaching Test Program, by Robert Merritt, Hal Peterson, Charles Wentz, Thomas Licht, and Michael Harris. February 1980. 130 pp. 33 figs. There is considerable interest in developing leaching techniques for low-grade uranium ores. For this study, a 2,500-ton low-grade uranium ore heap was tested to determine suitability of the heap leach extraction technique as a means of recovering uranium values. The results were compared with column leaches of the same ore. Flow rates were similar, and 96 pct of the uranium was leached in each system. Research done under Contract No. H0252022 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., 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 81–129751; paper copy price code A07.

OFR 118–80. Measurement and Control of Respirable Dust in Mines, by National Academy of Sciences. 1980. 405 pp. 164 figs. As result of

continuing national concern about the problem of respirable dust in underground mining operations, the National Materials Advisory Board formed a committee to prepare a study addressing the problem in a broad and fundamental manner. The objective of the study is to consolidate the information currently available on the subject, assess the active research program of the Bureau of Mines on the measurement and control of respirable dust in mines, and provide perspective settings for investigations needed in the future. This report describes the results of the study. Research done under Contract No. J0199002. 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 119–80. Development of New Chemistry for the Vapor Phase Extraction of Metals From Ores and Secondary Materials, by John P. Hager, Bruce Schiller, Stephen E. James, Kent O. Peaslee, Jerry Fasso, and William A. May. May 16, 1980. 175 pp. 38 figs. To add to the basic information bank on voltalization methods for recovering metals from ores, a study was made of vapor complexes such as Cu_2NaCl_3, $AuCu_2Cl_3$, $AgCu_2Cl_3$, $AgFeCl_4$, $PbFe_2Cl_8$, $ZnFeCl_5$, and $CdFe_2Cl_8$. A special inlet system was devised that allowed equilibrated high-temperature vapors from an atmospheric-pressure flow reactor to be leaked into the ion source of a time-of-flight mass spectrometer without compositional changes. A modified transpiration system allowed the carrier gas to be equilibrated with two different condensed samples. Vapor pressures were measured for some species, and enthalpies and Gibbs energy changes were measured for some vapor reactions. Discrepancies in JANAF tables data for Cu_3Cl_3 and $PbCl_4$ were discovered. The major loss of lead chloride from a fused-salt bath containing $PbCl_2$ was shown to be possible due to $PbOCl_2(g)$. In the volatilization of antimony from oxide mixtures, the vapor species $SbCO^+$ was observed; it was speculated that this may have come from $Sb_2O_2CO_3(g)$. Research done under Grant No. G0166021 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.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81-125320; paper copy price code A08.

OFR 120–80. The Effect of In Situ Retorting on Oil Shale Pillars, by Russell J. Miller, Fun-Den Wang, Thomas Sladek, and Chapman Young. March 1979. 194 pp. 58 figs. The objective of this investigation is to determine the physical and thermal properties of oil shale at elevated temperatures and to provide the required background information and analyses required for effective mine design and subsidence prediction for an in situ oil shale retorting operation. The reported tests were performed under varying conditions of temperature, confining pressures, and kerogen content. Tests were conducted on samples taken parallel and perpendicular to the bedding at a temperature range of 20° to 500° C, confining pressures up to 1,500 psi were applied, and kerogen content ranged from 10 to 30 gallons per ton. A review of current activity in the area of in situ retorting is included as an appendix and a comprehensive list of references for literature related to in situ retorting is provided. Research done under Contract No. H0262031 by Colorado School of Mines. Available for reference at Bureau of Mines facilities in Denver, Colo., Twin Cities, Minn., Bruceton and Pittsburgh, Pa., 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. Copies of this report will not be available for purchase.

OFR 121–80. Hydrothermal Precipitation of Boehmite From Aluminum Chloride Solutions, by Gopala N. Krishnan and Robert W. Bartlett. June 12, 1980. 30 pp. 7 figs. This report summarizes the results of phase I of a program to study the precipitation of boehmite from $AlCl_3$ solutions. The amount of boehmite precipitation from dilute $AlCl_3$ solutions is negligible below 200° C. Above 200° C the precipitation increases with increasing temperature approaching 40 pct at 300° C. Addition of HCl acid to the dilute $AlCl_3$ solution even in small quantities drastically reduces boehmite precipitation. Solution impurities such as Fe, Ca, Mg, or Na substantially promote the precipitation of boehmite. No precipitation is observed from concentrated $AlCl_3$ solution representing the leach liquor. Research done under Contract No. J0295025 by SRI International. 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 122(1)–80. Alumina Process Feasibility Study and Preliminary Pilot Plant Design. Task 3 Report: Preliminary Design of 25 Ton Per Day Pilot Plant. Volume I. Process Technology and Costs, by K. B. Bengston, P. Chuberka, R. F. Nunn, A. V. San Jose, G. M. Manarolis, and L. E. Malm. November 1979. 232 pp. 71 figs. This report provides the process technology, preliminary design, capital, and operating costs for a 25-ton-per-day pilot plant to produce cell-grade alumina using a clay-hydrochloric acid extraction-HCl gas induced crystallization process. The process was selected by the Bureau of Mines as the more promising method to produce cell-grade alumina from clay based on the results of two previous reports. The pilot plant process utilizes a unique dual crystallization process to produce aluminum-chloride-hexahydrate crystals with sufficient purity when decomposed to meet stringent alumina product specifications. The size of the pilot plant was selected to permit scaleup to commercial size plants of equipment, technical, and economic parameters. Research done under Contract No. J0265048 by Kaiser Engineers, 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.; and National Library of Natural Resources, U.S. Department of the In-

terior, Washington, D.C. Order ONLY from NTIS: PB 81-125031; paper copy price code A11.

OFR 122(2)-80. Alumina Process Feasibility Study and Preliminary Pilot Plant Design. Task 3 Report: Preliminary Design of 25 Ton Per Day Pilot Plant. Volume II. Appendix A. Equipment List, Specifications and Quotations. Areas 1 Through 7, by K. B. Bengston, P. Chuberka, R. F. Nunn, A. V. San Jose, G. M. Manarolis, and L. E. Malm. November 1979. 281 pp. This appendix contains the list of equipment selected for the capitol cost investment, with quotations from vendors and manufacturers, described in volume I of this six-volume report. A vendor response report with a separate equipment and motor list is included. Research done under Contract No. J0265048 by Kaiser Engineers, 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.; 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 122(3)-80. Alumina Process Feasibility Study and Preliminary Pilot Plant Design. Task 3 Report: Preliminary Design of 25 Ton Per Day Pilot Plant. Volume III. Appendix A. Equipment List, Specifications and Quotations. Areas 8 Through 25, by K. B. Bengston, P. Chuberka, R. F. Nunn, A. V. San Jose, G. M. Manarolis, and L. E. Malm. November 1979. 261 pp. This appendix contains the list of equipment, their corresponding numbers, and their specifications, with quotations from vendors and manufacturers who can supply the equipment, as described in volume I of this six-volume report. The listings are arranged by process plant areas. Research done under Contract No. J0265048 by Kaiser Engineers, 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.; 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 122(4)-80. Alumina Process Feasibility Study and Preliminary Pilot Plant Design. Task 3 Report: Preliminary Design of 25 Ton Per Day Pilot Plant. Volume IV. Appendix B. General Specifications, by K. B. Bengston, P. Chuberka, R. F. Nunn, A. V. San Jose, G. M. Manarolis, and L. E. Malm. November 1979. 201 pp. This appendix contains the general specifications for a 25-ton-per-day pilot plant as described in volume I of this six-volume report. Research done under Contract No. J0265048 by Kaiser Engineers, 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.; 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 122(5)-80. Alumina Process Feasibility Study and Preliminary Pilot Plant Design. Task 3 Report: Preliminary Design of 25 Ton Per Day Pilot Plant. Volume V. Appendix B. General Specifications, by K. B. Bengston, P. Chuberka, R. F. Nunn, A. V. San Jose, G. M. Manarolis, and L. E. Malm. November 1979. 122 pp. This appendix contains the general specifications for building descriptions and general design procedures for a 25-ton-per-day pilot plant as described in volume I of this six-volume report. Research done under Contract No. J0265048 by Kaiser Engineers, 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.; 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 122(6)-80. Alumina Process Feasibility Study and Preliminary Pilot Plant Design. Task 3 Report: Preliminary Design of 25 Ton Per Day Pilot Plant. Volume VI. Appendix C. Drawings, by K. B. Bengston, P. Chuberka, R. F. Nunn, A. V. San Jose, G. M. Manarolis, and L. E. Malm. November 1979. 103 pp. 96 figs. This appendix contains the general drawings of the various process areas as well as the buildings and the general arrangement of the 25-ton-per-day pilot plant described in volume I of this six-volume report. Research done under Contract No. J0265048 by Kaiser Engineers, 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.; 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 123-80. Evaluation of the Safety of One-Hour Chemical Self Rescuers, by R. W. Watson, W. J. Doyak, and A. L. Furno. November 1980. 184 pp. 70 figs. In January 1980, the Bureau of Mines initiated an experimental program to examine the fire and explosion hazards of 1-hour self-contained rescuers (SSRs). This action was prompted by a growing concern on the part of government and industrial safety officials over the potential hazards of these devices when deployed on a large scale in underground coal mines. Prior evaluation of the safety of these devices had been at best sporadic and usually limited to experimental models. The recent availability of preproduction models of a 1-hour SSR fabricated by the Mine Safety Appliance Co. and a production model manufactured by Dragerwerk Ag Lubeck of the Federal Republic of Germany allowed for a more comprehensive and meaningful evaluation of their safety in underground coal mines. This report summarizes the results of a 5-month study of the potential hazards of these two devices. Research done by Pittsburgh Research 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.; 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 124-80. Novel Concepts for Recovery of Nuclear-Grade Zirconium Oxide From Bureau of Mines Zirconyl Chloride Strip Liquors, by E. P. Stambaugh, J. F. Miller, and R. K. Smith. June 1980. 62 pp. 18 figs. Results of research on the hydrothermal precipitation of zirconium oxide from the Bureau of Mines zirconyl chloride-sulfate strip liquors indicate

that nuclear-grade material can be prepared by this process. Greater than 99 pct of the zirconium value can be precipitated at 250° to 260° C in short reaction time without consumption of acid value of the liquor. Thus, precipitation of zirconium dioxide on a continuous basis, that is, the zirconium dioxide is precipitated in a continuous mode of operation by pumping the strip liquor through a heated pressurized reactor and recycle of the acidic liquor to the process stage are favored. The results of accompanying studies of liquid-solid separation, product washing and dewatering, product purity, and chlorination of the product are presented and discussed. Research done under Contract No. J0295067 by Battelle Columbus Laboratories. 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 81-128837; paper copy price code A04.

OFR 125–80. Study of the Slate Mining Industry of Vermont/New York, by W. I. Watson, E. Ohlsson, C. E. Shorey, R. J. Miller, and A. J. Whittier. Oct. 15, 1980. 172 pp. 19 figs. This report presents results of a comprehensive analysis of the slate industry in Vermont-New York carried out to identify the present and future problems that are constraining the growth of the industry and to propose solutions to those constraints. All factors relevant to the industry's present and future status, such as markets and marketing techniques, competition from other producers both domestic and foreign, Federal and State regulations affecting the industry, quarrying and processing technologies, slate resources and reserves, and industry structure and economics were considered. Research done under Contract No. J0199075 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., 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 81-128936; paper copy price code A08.

OFR 126–80. Environmental Assessment of Surface Shortwall Mining, by Ernest W. Hilton and Michael Frakes. Dec. 21, 1979. 255 pp. 46 figs. The purpose of this investigation was to assess the environmental impact of the surface mining methods currently used in the steep-sloped areas of central Appalachia—southern West Virginia, eastern Kentucky, southwestern Virginia, and northeastern Tennessee. Comparisons are made between mountaintop-cross ridge mining, contour strip, augering, and an innovative method—surface shortwall mining that was attempted at Julian, W. Va. Included in the report are a discussion and analysis of current Appalachian production, reserves, and the extent of land affected on a county-by-county basis. Additionally, the seams within the steep-sloped region were assessed according to minimal standards of thickness, surrounding lithology, and areal extent to determine their amenability to surface shortwall mining. The seams were tabulated with their ash, sulfur, and British thermal unit content. Only minimal statements are made concerning quantity because of the narrow set of conditions required by the shortwall method. Other sections deal with the possible technical failings of an operational surface shortwall system based on field studies, discussions with people experienced with shortwalls, and research into ground control problems at sites where shortwall and longwall operations have been monitored. Research done under contract J0285033 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 81-128928; paper copy price code A12.

OFR 127–80. Improved Light-Scattering Dust Monitor, by Byron S. Kutscher. January 1980. 99 pp. 26 figs. This report summarizes a program to develop and construct an improved light-scattering dust monitor (ILSDM). The ILSDM, which operates on the forward light-scattering principle, provides instantaneous measurements of airborne dust concentrations in units of milligrams per cubic meter. The program was divided into two phases. The first involved the design of the ILSDM and the other included the fabrication of a prototype based on the design. A description of the final ILSDM design, operating conditions, maintenance instructions, and recommendations for additional work are included in the report. Research done under Contract No. H0377020 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 81-128829; paper copy price code A05.

OFR 128 80. Development of a Device for Evaluation of Resin Bolt Installations, by R. Lusignea, K. Maser, and M. McCoy. December 1979. 125 pp. 62 figs. This report describes the development of a device for nondestructive testing of resin-grouted roof bolts by mechanical frequency response. Various alternative methods were evaluated and the mechanical frequency response method was selected. An interactive program of design, testing, and development culminating in the current prototype instrument demonstrated the capabilities of the method and suggested potential applications. The resin bolt testing device utilizes a swept frequency dynamic compliance measurement in the 1 to 2 kHz range that is interpreted by an electronic signal processor to give a "GO" or "NO GO" readout. Field tests showed that the device can reliably determine the bond quality of the front half of the bolt (nearest the roof surface). Tests were carried out on both experimentally installed bolts and typical mine bolts installed by a conventional bolting machine. The program has led to recommendations for improve-

ment of the prototype and future development work. Research done under Contract No. H0166014 by Foster-Miller Associates, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., 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 81–130841; paper copy price code A06.

OFR 129–80. Recommended Acceptance Testing Criteria for Adhesives and Sealants for Explosion-Proof Electrical Enclosures, by P. H. Francis and J. Lankford. Jan. 9, 1980. 67 pp. 7 figs. Factors that currently enter into the design, manufacture, and quality assurance of explosion-proof enclosures are reviewed with special emphasis given to sealing concepts and sealants-cements for lenses. The physical and mechanical properties of a number of representative sealants and adhesives are measured, and found to exhibit great variance, with few discernible trends that might afford a firm base on which to establish minimum property standards. Acceptance criteria for adhesives and sealants are suggested based on the survivability of an explosion-proof enclosure as a structure rather than on the minimum material properties of its constituents. Procedures for surface preparation of adherends and quality assurance are also proposed. Research done under Contract No. H0387009 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 81–128738; paper copy price code A04.

OFR 130–80. Lincoln Terminal System Support Facilities Development, by R. C. Butman and W. P. Harris. July 17, 1979. 43 pp. 14 figs. The Lincoln terminal system (LTS) is a stand-alone computerized training device that presents high-quality visual displays and audio messages to students. A keyboard for student input and a variety of student-machine interactive programs are provided. The programs allow the author-instructor to evaluate numerical entries and responses to simple and compound multiple-choice questions (where a compound choice is defined to be more than one choice, ordered or unordered, from one or more lists of choices). Descriptions of LTS applications, lesson development procedures, hardware provided, and support facilities required are given. A contract history summary and a bibliography of reports published under three successive contracts supporting LTS development is provided. Research done under contract J0366078 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 81–130742; paper copy price code A03.

OFR 131–80. Interactive Mine-Power-System Analysis—APL Fault Program, by Frederick C. Trutt, Lloyd A. Morley, and Richard A. Rivell. Mar. 1, 1979. 109 pp. 6 figs. A guide to the development and utilization of an interactive mine-power-system fault program is presented. Theoretical foundations and implementation considerations are discussed with respect to the mine-power system. Alternative Kron reduction techniques are presented along with a triangular-storage method for storage conservation. Program capabilities include the analysis of balanced and unbalanced fault situations using symmetrical component theory. To account for phase shifting in delta-wye transformers and zero-sequence network constructions, transformer and load configurations are specified. The positive- and zero-sequence connections needed for network conformity are automatically constructed with the required impedances. Research done under Grant No. G0188035 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 81–130858; paper copy price code A06.

OFR 132–80. Steering System Survey for Surface Mining Equipment, by Jack L. Woodward, Lawrence L. Owens, Robert J. McCracken, and Peter I. Maté. Apr. 20, 1979. 186 pp. 51 figs. The expansion of mine production has required the development of larger and more productive loaders, scrapers, haulage trucks, and similar equipment. These machines have required the development and production of more powerful and complex steering systems. Careful analysis of these systems was warranted to determine if steering-related safety problems have been introduced. The objectives of this program were to define the specific types of steering systems now in use in wheeled surface mining equipment, gather information on the mining accidents resulting from malfunctions of equipment steering systems, estimate the relative numbers and sizes of mobile mining equipment in use, and to evaluate the need for new research projects or additional health and safety regulations. A comprehensive literature survey was conducted concurrent with extensive contacts with mining operations, mining equipment manufacturers, steering system component manufacturers, and government agencies. It was concluded that the steering systems in use on surface mining equipment are reliable and do not present a safety problem. Research done under contract J0275014 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 Morgan-

town, 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 81–130866: paper copy price code A09.

OFR 133–80. Noise Reduction of Chain Conveyors. Vol. I, by A. Galaitsis, R. Madden, and D. Andersen. December 1979. 144 pp. 56 figs. This report describes the noise source diagnosis of a Jeffrey 120M conveyor and the evaluation of several treatments all conducted in a test facility aboveground. The conveyor noise at the operator's position was gradually reduced from 101.5 to 93 dbA using damping, vibration isolation, sound barriers, and smoother discontinuities. Research done under Contract No. H0155113 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., 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 81–130833; paper copy price code A07.

OFR 134–80. Electrical Practices in Metal/Non-Metal Mines and Mills. Mine Power Systems, Mill Power Systems, Federal Regulations, Electrical Accidents, by David Bendersky and Vernon W. Klein. Mar. 4, 1980. 308 pp. 167 figs. The objectives of this study are to (1) survey electrical practices in metal and nonmetal mines and mills, (2) clarify the Federal regulations governing electrical practices, (3) analyze electrical accidents, and (4) make recommendations aimed at improving the safety of electrical practices. Information was obtained from literature searches, accident reports, visits to 27 mines and 12 mills, and discussions with knowledgeable industry and government people. The various electrical power systems and practices at the mines and mills visited are described. Similarities and differences based on the type of mining and the minerals being mined or milled are presented. The Federal regulations governing metal-nonmetal mine and mill electrical practices (Code of Federal Regulations, Title 30, Sections 55.12, 56.12, and 57.12) are presented and discussed. Explanations of each regulation are provided in an appendix. The attitudes of mine and mill operators towards the Federal regulations are described. An analysis of the electrical accidents in metal-nonmetal mines and mills during the period 1972–78 is presented. Recommendations including specific research and development activities aimed at improving electrical safety 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 81–130726; paper copy price code A14.

OFR 135(1)–80. Evaluation of Mine Roof Bolter Components. Volume I, by C. P. Fazio, W. J. Hargreaves, Jr., D. Kribs, and R. Wachtler. November 1978. 228 pp. 51 figs. The Bureau of Mines has made significant advances in developing roof bolter components to improve mining operation efficiency with respect to increased productivity and miner safety. Before now, no concentrated effort has been undertaken to systematically review and evaluate the results of these research activities and to utilize the advance designs generated in a total machine. This investigation researches Bureau-funded roof bolting component design contracts and commercially conducted research activities. Mining conditions considered for advance design application are low, medium, and high seam heights; rotary, rotary-percussive, and percussive drilling requirements of overburden; and bolting length capability of both less than seam height and greater than seam height. Six roof bolting system concepts are generated that meet these defined conditions and that encompass those roof bolting components considered most promising as a result of trade-off analyses performed. Research done under Contract No. H0272044 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. Copies of this report will not be available for purchase.

OFR 135(2)–80. Evaluation of Mine Roof Bolter Components. Volume II, by G. J. Hundman. November 1978. 122 pp. Analyses are presented for 24 roof bolter research projects for the system development costs and schedules to integrate advance design roof bolter components into a prototype second-generation roof bolter chassis. Data on existing roof bolter machine and utility vehicle chassis that were potential candidates for modification and component installation are also provided. Research done under Contract No. H0272044 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. Copies of this report will not be available for purchase.

OFR 136–80. Field Test of Hydraulic Borehole Mining Systems in Shallow Uranium Sands, by William R. Archibald. September 1978. 217 pp. 75 figs. This report presents the results of a program demonstrating the technical and economic feasibility of hydraulic borehole mining of uraniferous sandstone. A high-pressure cutting jet and a slurry jet pump make up the borehole mining tool, which is lowered down a borehole into the uranium-bearing sandstone. Water from the cutting jet cuts into the sandstone formation generating a water-sand slurry which is pumped to the surface, thereby forming a cavity in the formation. When the cavity size

reaches a point beyond the effective radius of the cutting jet, the mining tool is moved to an adjacent borehole and the process is started again. Research done under contract H0272010 by Flow Industries, Inc. Available for reference at Bureau of Mines facilities in Tuscaloosa, Ala., Denver, Colo., Avondale, Md., 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 81–128969; paper copy price code A10.

OFR 137–80. 1979 Survey of Respirable Dust Control Research in Underground Coal Mines, by J. A. Kost and A. G. Mayton. May 1980. 145 pp. 5 figs. A survey of 80 coal producers was conducted to determine the extent and scope of respirable dust control research for underground coal mines and the current methods employed to control respirable dust. Results of the survey showed that proper face ventilation and an adequate water spray system are sufficient to comply with mandatory standards in room-and-pillar mining. Difficulties still exist with longwall equipment, auger miners, and boring machines. In these cases, known dust control techniques are not sufficient to obtain compliance. Present state-of-the-art face ventilation and water systems are discussed in addition to the sampling program. Research done under Contract No. J0199046 by Bituminous Coal 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 81–130106; paper copy price code A07.

OFR 138–80. Kinetics of Chlorine Leaching of Zinc-Lead Flotation Concentrates, by James L. Hendrix. Feb. 4, 1980. 25 pp. 11 figs. This report presents results of investigations on the kinetics of leaching zinc-lead concentrates with chlorine. The objective was to determine the kinetic order and mechanisms involved in the reactions between sphalerite (zinc sulfide) and galena (lead sulfide) with chlorine. The influence of copper on the extraction rates also was studied. The rates of reaction for both species were zero order at 100° C, the rate limiting step being the chemical reaction. The addition of cupric chloride increased the extraction of both zinc and lead. Research done under Grant No. G0284004 by University of Nevada. 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.; and National Library of Natural Resources, U.S. Department of the Interior, Washington, D.C. Order ONLY from NTIS: PB 81–132482; paper copy price code A02.

OFR 139–80. Remote Sealing System Field Demonstration, by Steven R. Ruggieri and Adi Guzdar. June 1980. 65 pp. 21 figs. This report describes the work performed and results obtained during a field demonstration of a remote sealing system at the Bureau of Mines Jenny Mine near Inez, Ky., in the fall of 1978. Although portions of the remote sealing system has been used on a number of prior occasions, the demonstration at Jenny Mine marked the first use of the complete upgraded system including the use of an inert gas generating system for seal placement and the first application of a new froth foam system. The objective of the demonstration was to demonstrate the complete system by emplacing and evaluating several complete underground seals under conditions representing those of a mine fire situation. Of several critical sealing conditions identified, including high entry air flow, standing water in the entry, flowing water, irregular roof, and sealing a four-way intersection, four seals were successfully placed. Research done under Contract No. H0188105 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 81–132490; paper copy price code A04.

OFR 140(1)–80. Availability of Copper, Nickel, Cobalt and Manganese From Ocean Ferromanganese Nodules (II), by M. B. Fisk, J. Z. Frazer, J. S. Elliott, and L. L. Wilson. Aug. 24, 1979. 63 pp. 2 figs. Manganese nodule and crust elemental chemical data added to the Scripps Institution of Oceanography Sediment Data Bank from September 1978 through July 1979 are listed. The data include 280 samples assayed in the laboratory and 755 assays extracted from the literature. All available nodule abundance data are also listed. Characteristics and trends in the data are noted. Research done under Grant No. G0264024 by Scripps Institution of Oceanography. 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 81–145963; paper copy price code A04.

OFR 140(2)–80. Availability of Copper, Nickel, Cobalt and Manganese From Ocean Ferromanganese Nodules (III), by J. Z. Frazer and M. B. Fisk. Aug. 31, 1980. 112 pp. 22 figs. Manganese nodule elemental chemical data added to the Scripps Institution of Oceanography (SIO) Sediment Data Bank during the period September 1, 1978, to August 31, 1979, are listed. The data include compositions of 388 samples analyzed at SIO and 845 analyses taken from the literature. Information on analytical methods utilized for all nodule analyses stored in the data bank and their estimated precision and accuracy is presented. Data summaries for potential resource areas in the northeastern equatorial Pacific Ocean are updated to include information obtained in the past 2 years. Data summaries and maps of nodule distribution are presented for resource evaluation of additional areas in the Pacific and Atlantic Oceans. Research done under Grant No. G0264024 by

Scripps Institution of Oceanography. 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 81–145971; paper copy price code A06.

OFR 141–80. Manganese Nodule Deposits in the Indian Ocean, by J. Z. Frazer and L. L. Wilson. Sept. 1, 1979. 70 pp. 16 figs. Available data on nodule composition and abundance in the Indian Ocean are presented. Five areas in which nodule deposits might meet the criteria for consideration as mineral resources are discussed. Only one of these areas, in the Central Indian Basin, offers possible sites for first generation seabed mining; the others are submarginal. It is extremely unlikely that minable deposits occur in the Indian Ocean outside of the areas studied. Research done under Grant No. G0264024 by Scripps Institution of Oceanography. 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 81–145849; paper copy price code A04.

OFR 142–80. Geological Factors Related to Characteristics of Seafloor Manganese Nodule Deposits, by J. Z. Frazer and M. B. Fisk. Apr. 30, 1980. 41 pp. 16 figs. The effect of geological factors such as environment of deposition, sediment type, water depth, and local topography on nodule abundance and composition are studied. Statistical analyses of data from the SIO Sediment Data Bank are presented. Nodule abundance is shown to be strongly dependent on sedimentation rates, with the most abundant deposits occurring where the sedimentation is lowest. Copper enrichment in nodules is found to be due to the concentration of this element by planktonic organisms which are limited to equatorial regions. Cobalt enrichment, generally greater in crusts than in nodules, is shown to be associated with volcanic seamounts in the mid-Pacific region. Regional variations in nickel and manganese contents, local variations in composition and abundance, and the inverse correlation between grade and abundance are discussed. Research done under Grant No. G0264024 by Scripps Institution of Oceanography. 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 81–145831; paper copy price code A03.

OFR 143–80. Determination of In Situ Horizontal Rock Stress on Both a Mine-Wide and District-Wide Basis, by Jose F. T. Agapito, Scott J. Mitchell, Michael P. Hardy, and William N. Hoskins. Mar. 1, 1980. 175 pp. 59 figs. Several underground coal mines currently operating in the Beckley district of West Virginia are experiencing serious roof and floor problems. A significant portion of the estimated 2 billion tons of coal resources may be lost as a result of these ground control problems. Preliminary studies by the Bureau of Mines indicated that these are due in part to a high horizontal stress field. Using the Bureau's strain-relief overcoring technique, 14 overcoring sites in five mines were drilled producing 53 data sets. Analysis of the data was done to provide in situ horizontal stresses for each of the five mines and for the district as a whole. Stress data indicate horizontal stresses far in excess of that predicted by theory and in some cases, up to six times the estimated vertical stress. Research done under Contract No. J0285020 by Tosco Research, Inc., and J. F. T. Agapito & 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 81–139735; paper copy price code A08.

OFR 144–80. Feasibility of Fatigue Assessment of Block Walls From Laboratory Scale Methods, by Robert M. Koerner and Jack L. Rosenfarb. Sept. 1, 1980. 99 pp. 39 figs. The feasibility of using small-scale models to simulate residential masonry foundation walls subject to fatigue loading was investigated. Five wall segments were modeled in one-quarter scale using dynamic similitude equations. The walls were dynamically loaded using a sinusoidal base motion and wall accelerations were monitored. The stiffness, natural frequency of response, and damping characteristics were measured. The number of cycles of testing necessary to cause initial visible cracking was recorded. Analysis of the data indicated the importance of the relationship between the forcing function and the natural frequencies of the structure in influencing cracking damage. Research done under Contract No. J0285013 by Drexel 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., 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 81–140139; paper copy price code A05.

OFR 145–80. Instability of Contoured Surface-Mined Landscapes in the Northern Great Plains: Causes and Implications, by Gerald H. Groenewold and Bernd W. Rehm. Sept. 1, 1980. 26 pp. 12 figs. Reclamation of surface-mined landscapes is commonly defined only in terms of biological productivity. Other critical concerns associated with surface mining include the long-term quality of groundwater and stability of the postmining landscape. Meaningful reclamation design must address all of these concerns. Reconnaissance of postmining landscapes indicates three types of instability occur in these settings including area-wide settling, localized collapse, and piping. Area-wide settling is most pronounced during the first year after contouring but appears in precontouring valley areas where frozen materials are contoured with a dozer. Although severe in some settings, development typically ends within 1 year. Piping appears to be a severe and long-term problem in some settings, usually beginning soon after contouring ceases and could continue for several years. In some postmining landscapes, piping has only started to develop after as many as 5 years of apparent stability. Piping is

controlled by a combination of physical and chemical conditions in the spoil. A key factor is the presence of highly dispersive materials in the near surface. Research done under Contract No. J0275010 by North Dakota Geological 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. Copies of this report will not be available for purchase.

OFR 146–80. Environmental Effects of Slaking of Surface Mine Spoils: Eastern & Central United States, by D. E. Andrews, J. L. Withiam, E. F. Perry, and H. L. Crouse. September 1980. 250 pp. 44 figs. The objective of this study was to investigate the environmental effects of slaking of surface mine spoils. Both field and laboratory programs were undertaken supplemented by a literature search. The field program consisted of drilling the highwall as well as test pitting in recent 2-, 5-, and 10-year-old spoil piles at four active mining sites in the eastern bituminous coal fields. Pertinent observations were made and samples collected for laboratory analysis consisting of several standard geotechnical, agronomic, and geochemical tests. Durability tests included jar slake, cyclic wet-dry, rate of slake, and slake durability tests. Correlation between field and laboratory portions was made and the results presented. The report concludes with a discussion of the slaking process and associated environmental impacts, proposal of a preliminary classification system for use in premine planning, and presentation of management techniques to optimize the slaking process. Research done under Contract No. J0285024 by D'Appolonia Consulting Engineers, 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 81–168718; paper copy price code A11.

PATENTS

The following patents were granted to the Bureau of Mines during the period January 1 to December 31, 1980. 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 use of any of the patents should be made to the Branch of Patents, Division of General Law, Office of the Solicitor, U.S. Department of the Interior, Washington, D.C. 20240.

P 1–80. Method of Recovering Lead Through the Direct Reduction of Lead Chloride by Aqueous Electrolysis. M. M. Wong and F. P. Haver. U.S. Pat. 4,181,588, Jan. 1, 1980.

P 2–80. Removal of Asbestos Fibers From Water. J. E. Schiller and S. E. Khalafalla. U.S. Pat. 4,181,607, Jan. 1, 1980.

P 3–80. Catalyst for Synthesis of Methanol. E. G. Baglin, G. B. Atkinson, and L. J. Nicks. U.S. Pat. 4,181,630, Jan. 1, 1980.

P 4–80. Process for Producing a Metastable Precursor Powder and for Producing Sialon From This Powder. B. W. Jong. U.S. Pat. 4,184,884, Jan. 22, 1980.

P 5–80. Method of Continuously Determining Radiation Working Level Exposure. R. F. Droullard and R. F. Holub. U.S. Pat. 4,185,199, Jan. 22, 1980.

P 6–80. Froth Flotation of Insoluble Slimes From Sylvinite Ores. P. Thompson, J. L. Huiatt, and D. C. Seidel. U.S. Pat. 4,192,737. Mar. 11, 1980.

P 7–80. Process for Scavenging Iron From Tailings Produced by Flotation Beneficiation and for Increasing Iron Ore Recovery. A. F. Columbo and D. M. Hopstock. U.S. Pat. 4,192,738, Mar. 11, 1980.

P 8–80. Ventilation System for Automated Mining Machines. J. E. Matta and F. N. Kissell. U.S. Pat. 4,200,036, Apr. 29, 1980.

P 9–80. Induced Air Flow Self-Cleaning Spray Nozzle. J. E. Fraley, E. F. Sommers, S. Strang, and W. C. McConnell. U.S. Pat. 4,200,232, Apr. 29, 1980.

P 10–80. Method of Anchoring a Vibrating Wire Into a Hollow Gauge Body. I. Hawkes. U.S. Pat. 4,203,192, May 20, 1980.

P 11–80. Electrical Cable Coupler With Rotatable Protective Covers. C. D. Bice, J. H. Cooper, and M. L. Fenger. U.S. Pat. 4,203,640, May 20, 1980.

P 12–80. Froth Flotation Using Lanolin Modifier. J. M. Gomes, D. A. O'Keefe, and R. M. McAlexander. U.S. Pat. 4,208,275, June 17, 1980.

P 13–80. Dilution Stable Water Based Magnetic Fluids. S. E. Khalafalla, G. W. Reimers, and S. A. Rholl. U.S. Pat. 4,208,294, June 17, 1980.

P 14–80. Desorption of Gold From Activated Carbon. H. J. Heinen, D. G. Peterson, and R. E. Lindstrom. U.S. Pat. 4,208,378, June 17, 1980.

P 15–80. Recovery of Metals From Atlantic Sea Nodules. J. E. Pahlman and S. E. Khalafalla. U.S. Pat. 4,208,379, June 17, 1980.

P 16–80. Portable Calibrator for D.C. Circuit Breakers. D. A. Paice. U.S. Pat. 4,209,739, June 24, 1980.

P 17–80. Apparatus for the Continuous Monitoring of Ground Bed Resistance. A. D. Coby and W. L. Cooley. U.S. Pat. 4,209,741, June 24, 1980.

P 18–80. High Frequency Lighting Inverter With Constant Power Ballast. D. A. Paice. U.S. Pat. 4,220,896, Sept. 2, 1980.

P 19–80. Method of Manufacturing a Gas Sensor. J. M. Parry and P. Raccah. U.S. Pat. 4,221,827, Sept. 9, 1980.

P 20–80. In-Situ Leach Mining Method Using Branched Single Well for Input and Output. W. C. Larson and R. J. Morrell. U.S. Pat. 4,222,611, Sept. 16, 1980.

P 21–80. Molybdenite Flotation. J. L. Huiatt, M. D. Shurtz, and G. M. Potter. U.S. Pat. 4,231,859, Nov. 4, 1980.

P 22–80. Recovery of Organic and Aqueous Phases From Solvent Extraction Emulsions. K. W. Moser, R. E. Siemens, and S. C. Rhoads. U.S. Pat. 4,231,866, Nov. 4, 1980.

P 23–80. Recovery of Metal Values From Lead Smelter Matte. R. G. Sandberg and T. L. Hebble. U.S. Pat. 4,231,993, Nov. 4, 1980.

P 24–80. Separation of Zirconium From Hafnium by Solvent Extraction. D. J. MacDonald. U.S. Pat. 4,231,994, Nov. 4, 1980.

P 25–80. Mine Face Ventilation System. E. F. Divers. U.S. Pat. 4,235,163, Nov. 25, 1980.

P 26–80. Recycling Spent Asphaltic Concrete. W. C. McBee and T. A. Sullivan. U.S. Pat. 4,239,547, Dec. 16, 1980.

P 27–80. Removal of Impurities From Clay. J. A. Eisele, D. J. Bauer, and P. R. Bremner. U.S. Pat. 4,239,735, Dec. 16, 1980.

P 28–80. Sorption of Tungsten From Alkaline Solutions. S. R. Borrowman and P. B. Altringer. U.S. Pat. 4,241,028, Dec. 23, 1980.

P 29–80. Electrolytic Stripping Cell. B. W. Dunning, Jr., and D. H. Chambers. U.S. Pat. 4,242,192, Dec. 30, 1980.

P 30–80. Removal of Sodium Sulfate From a Sulfate-Containing Sodium Chloride Solution in a Process for Separating Zirconium and Hafnium. R. A. Guidotti. U.S. Pat. 4,242,312, Dec. 30, 1980.

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ARTICLES IN OUTSIDE PUBLICATIONS

OP 1–80. Identification and Quantification of Asbestos and Other Mineral Particulates, by William J. Campbell. Proc. Symp. on the Impact of Federal Health, Safety, and Environmental Regulations on the Ceramic Industry, 81st Ann. Meeting, Am. Ceram. Soc., Cincinnati, Ohio, Apr. 30–May 1, 1979, December 1979, pp. 55–66. Optical and electron microscopic methods are compared for their identification and quantification of fibrous particles in air, water, and bulk samples. Limitations of the Federal regulatory optical counting procedures for asbestos are considered when applied to materials of interest to the ceramic industry.

OP 2–80. Impact of Recent Cobalt Supply Situation on Magnetic Materials and Applications, by G. Y. Chin, S. Sibley, J. C. Betts, T. D. Schlabach, F. E. Werner, and D. L Martin. IEE Trans. on Magnetics, v. MAG–15, No. 6, November 1979, pp. 1685–1691. In 1978, the cobalt market was thrown into a state of great uncertainty, with soaring prices, limited supply, and accelerating demand. A critical shortage threatened to develop but never really materialized. To a great degree, the prices cobalt commanded on the free market induced Zambia, after consultation with other producers, to hike its prices. The effect was self-perpetuating, with each pricing-tier increase, producer and free market, encouraging the other to escalate. In each instance, Zaire followed suit. These developments took place against a background of a lack of readily available effective substitutes. Barring unforeseen developments that could greatly reduce the available supply, such as a previous production shutdown that lasted for several months, the supply of cobalt is likely to remain tight, but not critically short, for the next several years. Prices are expected to remain relatively high. Over the long term, 1985 and beyond, prospects are good for more readily available cobalt at more reasonable prices. Domestic production of cobalt and mining of deep sea cobalt-bearing manganese nodules could satisfy domestic demand and eventually result in lower prices. Thus, the short-term outlook is rather pessimistic, while over the long term the present precarious situation could be reversed.

OP 3–80. Development of a Mine Shaft Fire and Smoke Protection Prototype System, by Guy A. Johnson. Proc. 3d West Virginia University Conf. on Coal Mine Electrotechnology, Morgantown, W. Va., Aug. 4–6, 1976, pp. 20–1—20–4. This report describes the efforts by the Bureau of Mines and FMC Corp. to define the mine shaft fire and smoke hazard problem, then design, fabricate, and in-mine test prototype hardware for a system that better protects miners and the mine than the shaft-collar rings now commonly used. The resulting mine shaft fire and smoke protection system involves both thermal and smoke detectors, remotely controlled smoke doors at the shaft station, and remotely controlled sprinklers. The system was successfully demonstrated by an actual fire test in the Silver Summit shaft near Wallace, Idaho, in the spring of 1975. Long-term, in-mine testing of alternative system designs is currently being conducted to show that the system has credibility as a reasonably priced, reliable piece of improved mining health and safety hardware.

OP 4–80. Fused-Salt Electrowinning and Electrorefining of Rare-Earth and Yttrium Metals, by E. Morrice and M. M. Wong. Miner. Sci. Eng., v. 11, No. 3, July 1979, pp. 125–136. Increasing demands for rare-earth and yttrium metals in the preparation of special alloys and other uses have greatly enhanced their status as industrial metals. In this paper, a review is made by the Bureau of Mines of fused-salt electrowinning of individual rare-earth metals, yttrium metal, and mischmetal from the respective chlorides and oxides. Preparation of alloys of yttrium metal and rare-earth metals by fused-salt electrolysis and electrorefining of yttrium metal is also included in this review. Particular attention is devoted to the problems encountered in the electrolysis and progress made in the development of the technology.

OP 5–80. Chemical Monitoring of the In Situ Leaching of a South Texas Uranium Orebody, by R. W. Potter II, M. A. Clynne, J. M. Thompson, V. L. Thurmond, R. C. Erd, N. L. Nehring, K. A. Smith, P. J. Lamothe, J. L. Seeley, D. R. Tweeton, G. R. Anderson, and W. H. Engelmann. U.S. Geol. Survey Open File Rept. 79–1144, 1979, 54 pp. The Federal Bureau of Mines and the U.S. Geological Survey measured the changes in formation water chemistry during the initial stages of in situ uranium leaching at a site in south Texas, using $(NH_4)_2CO_3$ as the leach solution. Cores and ground water were analyzed before leaching. Water samples were taken from test wells between injection and recovery wells as leach solution replaced the ground water. Measurements were made at least daily of temperature, pH, U, Na, K, Ca, Mg, SiO_2, NH_4, HCO_3, CO_3, SO_4, and Cl. The data were needed for developing and verifying a computer simulation model of the geochemical reactions involved in in situ uranium leaching.

OP 6–80. Acoustic Emission Techniques Applied to Slope Stability Problems, by Raymond M. Stateham and Robert H. Merrill. Rockslides and Avalanches Vol. 2. Engineering Sites, ed. by B. Voight; ch. 16 in Development in Geotech. Eng., v. 2, No. 14B., 1979, pp. 577–593. Techniques and instruments used to detect instability in rock masses around underground mines have been refined and applied to the detection of instability in rock slopes. From the number and magnitude of the acoustic emissions in the rock mass, engineering estimates of slope instability can be made. The electronic apparatus has advanced from early tube-type circuitry to solid-state circuitry capable of amplifying the output of accelerometers, velocity gages, and pressure gages used to detect acoustic emissions (rock noises). Some of the techniques, instruments, and results at four open pit mines are described. The results of these studies show that the techniques can be used to predict failure, monitor the progress of the failure, and provide evidence that earthquakes can affect the stability of a pit wall.

OP 7–80. Magnetic Properties of Mischmetal-(Co,Cu,Fe,Mg) Alloys, by J. W. Walkiewicz and M. M. Wong. IEEE Trans. on Magnetics, v. MAG–15, No. 6, November 1979, pp. 1757–1759. To relieve the dependence for critical and strategic minerals

through conservation and substitution, 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 selected MM-Co-Cu-Mg and MM-Co-Cu-Mg-Fe alloys were evaluated. Magnets were fabricated by powder metallurgy that consisted of arc-melting the metals, crushing and grinding the resultant alloy, alining and compacting the powder, and sintering the green compacts.

OP 8–80. Inhibition of Pyrite Weathering by Recycling of Selected Effluents, by Fraser M. Walsh, Robert L. Stone, and William H. Engelmann. Proc. Underground Coal Mining Symp., Coal Conf. and Expo V, Louisville, Ky., Oct. 23–25, 1979, pp. 139–146. Pyrite weathering is responsible for the large loads of acid and iron in streams associated with coal mine regions of Appalachia. This paper is derived from a study funded by the Bureau of Mines and describes briefly (1) the work done to verify the mechanics of weathering of pyrite entrained in fresh coal mine face material, (2) the importance of iron bacteria in catalyzing pyrite weathering, and (3) the successful laboratory test of a method for inhibiting these bacteria. Preliminary results of the ongoing laboratory tests are described. These results show that iron bacteria catalyze pyrite weathering by a factor of 4 and this catalysis can be stopped by increasing the iron concentration of water influent to the mine face material to 100 ppm. The technical basis for a practical field method for reducing by 80 percent the acid and iron loads from coal mine operations is described.

OP 9–80. Electron Radon Daughter Dosimetry, by John Durkin. Health Phys., v. 37, December 1979, pp. 757–764. Daily exposure of uranium mining personnel to ^{222}Rn daughters has established the need for a device that will continually monitor an individual's exposure. Such a device has been built and tested with promising results. The device is an electronic dosimeter using both a solid-state detector and circuitry, and is a personal instrument worn throughout the working shift. Since the instrument is in close proximity to the miner and measures continually, it provides a more accurate account of total cumulative exposure, and avoids the errors caused by the present technique of spot checking the environment. The system permits the measurement of cumulative exposures to airborne radon progeny, expressed in units of working level hours.

OP 10–80. Research on a More Effective Use of Mineral Resources—A Mission of the United States Bureau of Mines, by T. A. Henrie and F. Block. Proc. 2d Internat. Symp. on the Mineral Resources Potential of the Earth, Hannover, Federal Republic of Germany, Apr. 18–20, 1979, pp. 24–38. The standard of living in the United States and other industrialized nations depends heavily on mineral resources, particularly metals. Per capita consumption of metals is high, and it increases each year. The growth rate is most rapid in those countries that are just beginning to industrialize, which means greater competition for mineral resources than ever before. Therefore, it is imperative to conserve these resources by the most efficient use possible. This paper discusses some of the new mineral-processing technologies investigated by the Bureau of Mines in this vital mission.

OP 11–80. Wear-Resistant Materials for Coal Conversion Components, by J. E. Kelley and H. W. Leavenworth, Jr. Proc. 4th Ann. Conf. on Materials for Coal Conversion and Utilization, Gaithersburg, Md., Oct. 10–12, 1978, pp. III–32—III–37. The need for improved wear-resistant materials for valves, nozzles, and other wear-prone components has been demonstrated by frequent failures in gasification and liquefaction pilot plants. The key to the development or selection of improved materials is a thorough understanding of the behavior of existing materials in both laboratory and pilot plant environments. This Bureau of Mines paper presents results of research to evaluate materials in these environments, recommendations on the best currently available materials, and the use of accumulated data to develop better materials.

OP 12–80. Citrate Process Demonstration Plant—Construction and Testing, by Richard S. Madenburg, Laird Crocker, Laurance L. Oden, John M. Cigan, and R. Dean Delleney. Proc., Symp. on Flue Gas Desulfurization, Regenerable Processes Session, Las Vegas, Nev., March 1979, EPA–600/7–79–167b, v. 2, July 1979, pp. 761–791. This Bureau of Mines paper discusses the construction of the citrate process demonstration plant, the mechanical and prestartup testing, and the test and evaluation program. A brief description of the process, recent material evaluations, and an assessment of application of citrate technology to other industrial SO_2-emitting sources are presented.

OP 13–80. Demonstration of SO_2 Scrubbing of Flue and Stack Gases by Citrate Absorption, by William A. McKinney and W. I. Nissen. Pres. at Am. Min. Cong. Min. Conv., Los Angeles, Calif., Sept 23–26, 1979, 14 pp. The Bureau of Mines citrate process for scrubbing SO_2 from industrial waste gases comprises absorption of SO_2 from cooled and cleaned gases in a solution of sodium citrate, citric acid, and sodium thiosulfate, followed by reacting the absorbed SO_2 with H_2S to precipitate elemental sulfur and regenerate the citrate solution for recycle. Laboratory investigations established process parameters; then pilot plant testing at a copper smelter and a lead smelter confirmed process, operational, and performance parameters and established the design basis of commercial demonstration of the citrate process. The demonstration plant represents a joint Government-industry effort to apply the citrate process to an existing 60-Mw coal-fired, electricity generating powerplant. Construction of the demonstration plant was scheduled to be completed in August 1979, and acceptance testing was to start immediately afterwards. Following the plant acceptance test, plans call for the test and evaluation of the plant operation for 1 year.

OP 14–80. Projections and Forecasts of U.S. Mineral Demand by the U.S. Bureau of Mines, by V. Anthony Cammarota, Jr., William J. Mo, and Barry W. Klein. Proc. 109th AIME Ann. Meeting, Las Vegas, Nev., Feb. 24–29, 1980, pp. 69–71. The Bureau of Mines forecasting system consists of statistical and contingency analyses. Ordinary least-squares regression analysis is the statistical technique used to obtain U.S. demand projections for mineral commodities by end use categories in the year 2000. The year 2000 projections for the independent or explanatory variables used in these linear regressions are based on the Data Resources, Inc., macroeconomic model that forecasts gross national product and detailed Federal Reserve Board indus-

trial production indexes. Among the resulting regression lines that best explains the variation in the dependent variable is the one that is chosen and its associated end use projection in 2000 is published in the Bureau's Mineral Commodity Profile series. The other important component of the Bureau of Mines forecasting system is contingency forecasting that takes into account the judgmental factors. The effects on demand from such factors as technological advances, environmental issues, government policies and regulations, and consumer tastes are considered.

OP 15–80. Evaluation of the Methane Gas Content of Coalbeds: Part of a Complete Coal Exploration Program for Health and Safety and Resource Evaluation, by William P. Diamond. Proc. 2d Internat. Coal Exploration Symp., Denver, Colo., Oct. 1–4, 1978; Coal Explor., v. 2, 1979, pp. 211–222. The explosion hazard of methane-air mixture has become an increasingly serious problem in mine planning. As mining progresses to greater depths or develops in new, previously unmined areas, an advance assessment of methane gas potential can be essential for a safe and economic mine development program. The Bureau of Mines, as part of its Coal Mine Health and Safety Program, has developed a simple, inexpensive test to accurately measure the methane content of coal samples obtained from exploration cores. The gas content of the coal per unit weight determined by this "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. The test results also can be used to estimate the methane resources of coalbeds in specific geographic areas. With the eventual decline in conventional domestic gas production and increased price of natural gas, commercial production of coalbed gas will become a reality.

OP 16–80. Directional Drilling for Coalbed Degasification in Advance of Mining, by William P. Diamond and David C. Oyler. Proc. 2d Ann. Symp. on Methane Recovery From Coalbeds, Pittsburgh, Pa., Apr. 18–20, 1979, pp. 162–176. The Bureau of Mines has conducted research in directional drilling for degasification in advance of mining since 1973. This technique is designed to combine the highly successful underground horizontal degasification drilling technology with surface drilling methods. The use of directional drilling techniques will be particularly useful in areas where access to gassy coalbeds is not possible underground, and where topography makes multiple sites for vertical degasification holes impractical or prohibitively expensive. This report presents the development of the directional drilling technique in detail along with a description of the Bureau's current directional drilling program at the Emerald mine near Waynesburg, Pa.

OP 17–80. Ferric Chloride Leach-Electrolysis Process for Production of Lead, by M. M. Wong, F. P. Haver, and R. G. Sandberg. Proc. 1980 World Lead-Zinc Symp., Las Vegas, Nev., Mar. 27–29, 1980, pp. 445–454. The Bureau of Mines, under a cooperative research agreement with lead producers, is conducting a feasibility study of a process to minimize pollution caused by sulfur oxide and lead. The process involves ferric chloride leaching of galena to produce lead chloride and fused-salt electrolysis of the lead chloride to produce lead and chlorine. The chlorine produced by electrolysis is used directly to regenerate ferric chloride in the leach solution. The study is being conducted in a process development unit designed to produce about 500 pounds per day of lead metal, operating on an integrated basis. This report describes the equipment and operating procedures, and presents a preliminary evaluation of the results with respect to process performance, equipment corrosion, impurity buildup, and air monitoring.

OP 18–80. Production and Uses of Zinc, by V. Anthony Cammarota, Jr. Ch. in Zinc in the Environment. John Wiley & Sons, Inc., New York, pt. 1, 1980, pp. 1–38. The organization of the zinc industry is discussed with details given on mining, milling, smelting, and refining of zinc by various processes. The geology of major deposits are described. Environmental and economic factors in the industry are given. World mine and smelter data have been tabulated since 1950 to indicate trends in world production. The United States was the largest producer of zinc metal from 1901 to 1971, but has lost this position as smelters closed. Since 1951, U.S. production has shifted from the Western States to the Eastern States, with the result that a higher proportion of zinc is being extracted from zinc ores rather than mixed ores. The use of zinc as a metal, dust, and in compounds is described. U.S. demand is expected to grow at an annual rate of about 2 percent to the year 2000. After about 1990 zinc batteries for automobile propulsion and electrical load leveling could become important.

OP 19–80. Alaska's Minerals: A Look at 1979, by David Carnes. Alaska Construct. & Oil, January 1980, pp. 40–43. This article outlines mineral exploration, mining, and petroleum activity that occurred in Alaska during 1979. Small placer mines, located in the State's known gold placer districts, increased total production during the year, but reduced production from the leading gold producer caused an overall decline in total gold production. Sand and gravel production, coupled with crushed stone, produced the largest revenues in the mineral industry. Coal production was limited to a single operation that produced approximately 730,000 short tons of coal. Mineral exploration was at a slightly reduced level compared with the previous year. Major companies explored on the Seward Peninsula, the De Long Mountains, Brooks Range, Interior Alaska, and Southeastern Alaska. Extensive exploration for outlining ore body configuration occurred at Greens Creek and Quartz Hill. Daily oil production during 1979 reached over 1.4 million barrels per day, putting Alaska in 2d place among the 50 States for daily oil production. The proposed natural gas line received approval by the Department of the Interior, but actual construction is running into financial difficulties. The first oil and gas lease sale since 1974 was conducted during 1979.

OP 20–80. Recovery of Byproduct Heavy Minerals From Sand and Gravel Operations in Central and Southern California, by J. M. Gomes, G. M. Martinez, and M. M. Wong. Proc. Mineral Resource Potential of California Conf., Sacramento, Mar. 27–28, 1980, pp. 54–70. The Federal Bureau of Mines has investigated the occurrence and recovery of byproduct heavy minerals from sand and gravel operations as a means of assessing the Nation's resources. Sand samples from 63 locations in central and southern California were treated to yield heavy mineral concentrations. The mineral compositions of the concentrates were characterized by chemical and mineralogical examinations. Additional large quantities

of concentrates were prepared from selected deposits that contained significant quantities of heavy minerals. Beneficiation studies were performed on these concentrates to recover individual mineral products. Gold was recovered by amalgamation; platinum-group metals and radioactive minerals were recovered by flotation; and magnetite, ilmenite, and chromite were recovered by magnetic and high-tension separation techniques.

OP 21–80. Recovering Byproduct Heavy Minerals From Sand and Gravel Operations in Northern California, by J. M. Gomes, G. M. Martinez, and M. M. Wong. Proc. Aggregate, Sand and Gravel Conf., Reno, Nev., May 5–9, 1979, pp. 4–33. The Bureau of Mines, as part of an effort to maximize minerals and metals recovery from domestic resources, has investigated sand and gravel, placer gold, and industrial mineral operations in northern California. Sand samples from about 50 locations were treated by gravity separation to yield heavy mineral concentrates (black sands). Mineral compositions of the concentrates were determined by chemical analysis and mineralogical examination. Individual zircon, ilmenite, magnetite, platinum-group metals, thoria, and silica products were prepared from heavy mineral concentrates by selective separation using low- and high-intensity magnetic, high-tension, and flotation equipment.

OP 22–80. Pneumatic Beneficiation of Mica Ores, by C. E. Jordan, G. V. Sullivan, and B. E. Davis. Pres. at Soc. Min. Eng., AIME, Ann. Meeting, Las Vegas, Nev., Feb. 24–28, 1980, SME Preprint 80–7, 8 pp. The Bureau of Mines, as part of its effort to maintain an adequate supply of minerals and metals to meet national economic and strategic needs, is conducting research on the pneumatic recovery of coarse mica. A system of crushers, screens, and zigzag air classifiers is used to concentrate coarse liberated mica particles from mica ore and from the waste tailings of abandoned mica operations. The plus 0.21-mm-size mica is effectively recovered by this method. The mica concentrates produced contain over 90 pct mica. The method recovered up to 78 pct of the mica in the samples. As a dry concentration method, the pneumatic beneficiation technique may be advantageous to areas of limited water resources.

OP 23–80. Recycling of Waste Magnesite-Chrome Refractories, by E. Martin and A. V. Petty, Jr. Pres. at TMS-AIME Ann. Meeting, Las Vegas, Nev., Feb. 24–28, 1980; TMS Paper Selection A80–40, March 1980, 15 pp. The Bureau of Mines, as part of its program to conserve mineral resources through secondary resource recovery, determined the feasibility of recycling magnesite-chrome refractories from copper and steel furnaces. Physical and chemical beneficiation processes were investigated to remove contaminants prior to recycling. Samples of the beneficiated material were formed into briquets, and modulus of rupture data were determined.

OP 24–80. A Bureau of Mines for the 80s, by Lindsay D. Norman. Min. Cong. J., Reprint, December 1979, 4 pp. The paper presents a general explanation of the recent reorganization of the Bureau of Mines and attempts to convey a meaningful understanding of the new organization. New purposes and principal ways in which the Bureau can more effectively serve the public interest are described along with an idea of the Bureau's objectives and the importance of individual efforts in attaining them.

OP 25–80. Criterion of Failure for Design of Rock Mass Structures as Determined by Borehole Shear Tests, by Louis A. Panek. Proc. 4th Cong., Internat. Soc. for Rock Mechanics, Montreux, Switzerland, Sept. 3–7, 1979, pp. 509–515. To meet the need for improved field test instruments, hardware and procedures were developed for rapidly determining the in-place shear strength of coal and rock. The hydraulically operated device is permissible, portable, and can be used in 3-inch boreholes at depths up to 100 feet. Field tests in a number of mines, coal, nonmetallic, and hard rock, show that the tester is practical for mine use, especially where recovery of unbroken core for laboratory tests would be difficult. In addition to eliminating the "good rock only" bias inherent in laboratory testing, the tester offers the advantages that many tests can be quickly performed in a single borehole and the results are available immediately. A technical paper presented to an international meeting in 1979 shows that the test data obtained for four different coals and four rock types are equivalent to those for conventional triaxial tests, the best laboratory strength test. The shear strength of coal and rock is important in determining pillar crushing, floor heaving, overburden collapse, roof bolt anchorage, and cutability and drillability of the materials.

OP 26–80. Recovery of Barite From Tailings Ponds and Bypassed Mining Waste, by G. V. Sullivan and W. E. Lamont. Pres. at Soc. Min. Eng., AIME, Ann. Meeting, Las Vegas, Nev., Feb. 24–28, 1980, 5 pp. As part of its program to conserve domestic mineral resources through advancing mineral resources technology, the 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 pct $BaSO_4$ with recoveries of 86 and 96 pct, 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 pct $BaSO_4$ with an attendant recovery of 97 pct of the barite.

OP 27–80. Preparation of Dilution-Stable Aqueous Magnetic Fluids, by Sanaa E. Khalafalla and George W. Reimers. Pres. at 2d Internat. Conf. on Magnetic Fluids, Orlando, Fla., Mar. 24–27, 1980; IEEE Trans., v. MAG-16, No. 2, March 1980, pp. 178–183. The extension of the Bureau-developed peptization technique for kerosine-base fluids to the preparation of the aqueous variety was possible when oleic acid was replaced by dodecylamine. The fluids thus prepared were, however, not stable toward dilution. When dodecanoic (lauric) acid was used instead of dodecylamine as the dispersing agent, the resulting aqueous magnetic fluid was found to be more stable toward dilution with water. In this second generation water-base magnetic fluid, the dodecanate anionic dispersing agent is superior to the commonly used dodecylamine cationic dispersing agent. Chemisorption of dodecanate anion on the magnetite surface proper by chemically bonding to surface iron atoms is contrasted to the mere adsorption of a cationic surfactant on the solution side of the electric double layer.

OP 28–80. Characteristics of a Potassian Winchite-Asbestos From the Allamoore Talc District, Texas, by Ann

G. Wylie and Charles W. Huggins. Can. Mineral., v. 18, February 1980, pp. 101–107. Asbestos from the Diablo prospect, Allamore talc district (Texas) has cell dimensions a 9.944(5), b 17.951(6), c 5.271(4) A, β 104.41(5)° (powder-diffraction data); the data are consistent with space groups $C2$, Cm, or $C2/m$. Chemical analyses indicated a potassian winchite-asbestos, $(K_{0.43}Na_{0.02})$ $(Na_{1.12}Ca_{0.68}Mg_{0.20})$ $(Mg_{4.82}Al_{0.11}Fe^{3+}_{0.07})$ $(Si_{7.99}Al_{0.01})$ $O_{21.55}(OH_{1.88}F_{0.51})$. Low indices of refraction, $na' = 1.576$ to 1.596, $n\gamma' = 1.590$ to 1.600, are probably related to the presence of fluorine and the low Ca and Fe contents. EDAX indicates that their variability is related to Na, K, Ca, and Mg contents. In composition, this asbestos probably ranges from a potassian richterite to a potassian winchite. The asbestos habit is here well developed: fibers are composed of fibrils 200 to 400 A wide, oriented with c axes parallel, but with no preferred orientation of a and b. This fibril-bundle structure explains the optical properties of parallel extinction and anomalous interference figures. This asbestos is considered a product of low-temperature metasomatism of a siliceous dolomite. The chemical and physical characteristics described here are consistent with this interpretation.

OP 29–80. Electrical Energy Required to Cut and Deliver Coal Out of a Continuous Miner Section, by George J. Conroy and James H. Green. Trans. Soc. Min. Eng., AIME, v. 266, 1980, pp. 1929–1935. Results of a long-term program of electrical parameter measurements in underground coal mine working sections, performed by the Pennsylvania State University under Bureau of Mines sponsorship, are utilized as the basis for an analysis of the electrical energy requirements during operation. A model section is hypothesized, developed from the average or most representative characteristics as determined from tabulations of the measurements. Performance factors of the model section's machine complement are then analyzed, particularly with regard to the energy required per ton of raw coal cut and delivered from the section. Results are given in kilowatt-hours per ton.

OP 30–80. Gearing Up To Control Trace Elements During Mineral Processing, by Thomas A. Henrie. Min. Cong. J., v. 66, No. 4, April 1980, pp. 18–20. Gearing up to control trace elements during mineral processing involves obtaining all the information available about the operations of the various processors. This Bureau of Mines paper describes the need for precise terms and methodology needed for trace minerals, the environmental impact of polutants not documented, a matrix to identify problems, properties of chemical compounds and how they differ from component elements, and the confusion in assessing the need for environmental controls. The paper also describes why it is important for processors to know about the compounds at each step and how they can add body to existing knowledge.

OP 31–80. A Transient Dust-Flame Model: Application to Coal-Dust Flames, by Edward J. Kansa and Henry E. Perlee. Combust. Flame, v. 38, 1980, pp. 17–36. A transient model of dust combustion is presented in which processes such as solid pyrolysis, gaseous combustion, solid-gas combustion, radiation transport, mass and thermal diffusion, and convection have been considered. It is assumed that each dust particle and its immediate-gaseous envelope do not influence their nearest-neighboring similar systems. Application of this model to coal dust-air mixtures yields results in good agreement with the experimental observations of other researchers.

OP 32–80. Vegetative Stabilization Tests on an Acidic Copper Tailing, by W. R. McDonald and M. B. Shirts. Pres. at SME-AIME Fall Meeting and Exhibit, Tucson, Ariz., Oct. 17–19, 1979, SME Preprint 79–321, 8 pp. The Bureau of Mines conducted field tests on acidic copper tailing as part of its program to devise, improve, and demonstrate technology for stabilizing mining and mineral processing wastes. Results are presented from successful 1/8- and 1-1/2-acre demonstration revegetation plots established in 1973–74 on an abandoned copper tailing pond located on public land adjacent to Holden Village, Wash. The tailing was neutralized with treatments of either dolomitic lime or limerock and fertilized with processed sewage sludge and/or commercial fertilizer. Plant growth covering 60 percent of the surface was achieved on both test plots. Regar brome, Tegmar intermediate wheatgrass, and tall wheatgrass provided the best plant growth and surface coverage. In neutralizing the tailing, the pH of 6.8 was not achieved; however, good plant growth occurred in areas where the pH ranged from 2.9 to 5.8.

OP 33–80. Preparation of Specialty Ferrochromium (9 Wt. %C) From a Domestic Chromite, by Philip E. Sanker, Ralph H. Nafziger, and George H. Reynolds. J. Metals, v. 32, No. 1, March 1980, pp. 49–52. An example of studies by the Bureau of Mines to develop technology to tap domestic sources of critical minerals is presented. Ferrochromium containing 62.5 wt-pct Cr and 9.1 wt-pct C was produced from a domestic chromite using an open-bath technique in an electric furnace. The high-carbon ferrochromium product in powder form was successfully tested in fusion welding processes for hardfacing.

OP 34–80. Dewatering Fine-Particle Suspensions With Direct Current, by Richard H. Sprute and Dennis J. Kelsh. Pres. at Soc. Min. Eng., AIME, Meeting, Las Vegas, Nev., Feb. 24–28, 1980; proc. Fine Particles Processing Symp., American Institute of Mining, Metallurgical, and Petroleum Engineers, Inc., New York, v. 2, ch. 91, May 1980, pp. 1828–1844. Slow-setting, fine-grained suspensions can often be dewatered and densified by applying direct current between buried electrodes. Although water removal rates and power expenditures depend on physical and chemical properties of the treated slurries, metal mine tailings from Idaho, Colorado, and Mexico have responded well in laboratory testing, as have 29 samples of ultrafine coal waste from mines in nine States. This Bureau of Mines report reviews field tests at two Idaho metal mines and describes the recent installation at the Henderson molybdenum mine near Empire, Colo., and the treatment of coal sludge at a Clinchfield Coal Co. preparation plant near Dante, Va.

OP 35–80. Underground Mine Evacuation Plans Analyzed by Computers, by Douglas Tesarik, David Nicholson, and A. B. Boghani. Mine Safety and Health, Mining Safety and Health Administration, v. 4, No. 5, October-November 1979, pp. 14–16. The most important element in escaping from an underground mine during fires and other emergencies is an effective evacuation strategy and plan. The Bureau of Mines has developed a computer program to evaluate and construct mine evacuation procedures

and plans. The paper illustrates the program's application for practical use by the mining industry.

OP 36–80. ROPS Field Performance—A Status Report, by Jack L. Woodward and Stephen Swan. Pres. at Earthmoving Industry Conf., Central Illinois Section, Peoria, Ill., Apr. 14–16, 1980; SAE Tech. Paper 800679, 9 pp. The question, "Are ROPS providing adequate operator protection?" is addressed by conducting analyses of rollover accidents and reviewing ROPS certification test data. It was found that ROPS generally exceed structural performance requirements and do reduce the number of injuries and deaths due to rollovers on mining and construction machines. It was also determined that the severity of rollovers vary widely between different types of machines, that quality control during ROPS fabrication is very important, and the chances of surviving a rollover are enhanced substantially by wearing a seat belt.

OP 37–80. Drilling Long Horizontal Coalbed Methane Drainage Holes From a Directional Surface Borehole, by William P. Diamond and David C. Oyler. Pres. at SPE/DOE Symp. on Unconventional Gas Recovery, Pittsburgh, Pa., May 18–21, 1980, SPE Preprint 8968, pp. 341–346. Three primary horizontal methane drainage holes totaling 2,428.4 meters (7,967 feet) have been completed in the Pittsburgh coalbed from a directional surface borehole. Directional control and sidetracking techniques developed during the project increased the horizontal drilling rate from 24.4 meters (80 feet) per day initially to 64.9 meters (213 feet) per day on the third horizontal hole. Drilling data indicate that horizontal holes can be drilled substantially longer than the maximum 977 meters (3,207 feet) achieved.

OP 38–80. Influence of Coalbed Characteristics and Geology on Methane Draining, by Gerald L. Finfinger, Leonard J. Prosser, Jr., and Joseph Cervik. Pres. at SPE/DOE Symp. on Unconventional Gas Recovery, Pittsburgh, Pa., May 18–21, 1980, SPE Preprint 8964, pp. 319–324. Methane drainage in advance of mining using horizontal holes continues to expand. Interpretation of coalbed characteristics and geology in relation to drilling procedures and gas flows will provide additional information for further development of this technique. A study conducted in the Pittsburgh coalbed at Bethlehem Mines Corp., Marianna mine 58, showed the effect of coalbed discontinuities, such as clay veins and sandstone channels, on drilling of horizontal boreholes, and on gas flows. It has shown the need to adapt drilling techniques to the varying degrees of hardness encountered within the same coalbed.

OP 39–80. Ilmenite Reduction by a Carbon Injection Technique, by R. H. Nafziger and R. R. Jordan. 37th Electric Furnace Conf. Proc., AIME, Detroit, Mich., Dec. 4–7, 1979, v. 37, July 1980, pp. 178–189. Declining domestic reserves of high-grade ores have stimulated interest in the efficient use of more plentiful materials such as ilmenites and titaniferous magnetites for the production of pigment-grade TiO_2 and raw materials for steelmaking operations. Materials containing high levels of TiO_2 cannot be used in blast furnace operations, owing to the formation of titanium carbide and/or nitride. These deposits increase the viscosity of the slag so that reduction reactions occur with difficulty. Success was achieved by reducing titaniferous materials in an electric-arc furnace under carefully controlled conditions. Traditionally, the preparation of charge materials for the reduction of titaniferous ores and concentrates in an electric-arc furnace was accomplished either by mixing the carbonaceous reductant with the charge or by pelletizing the reductant with the ore. In most cases, carbon utilization ranging from 29 to 39 pct were realized when coke was used with or without woodchips. Reserves of domestic coking coals were limited. Therefore, use of alternate byproduct or readily available reductants should be encouraged. In addition, conventional techniques for adding carbonaceous reductants to electric-arc furnaces often result in undesirable environmental degradation.

OP 40–80. Methane Drainage From the Mary Lee Coalbed, Alabama, Using Horizontal Drilling Techniques, by John H. Perry, Leonard J. Prosser, Jr., and Joseph Cervik. Pres. at SPE/DOE Symp. on Unconventional Gas Recovery, Pittsburgh, Pa., May 18–21, 1980, SPE Preprint 8967, pp. 335–340. The Bureau of Mines has developed several techniques for draining methane from coalbeds in advance of mining. Drilling long horizontal holes from an underground location is one of these techniques which has been successfully demonstrated in the Pittsburgh and Sunnyside coalbeds. A similar project was successfully conducted in the Mary Lee coalbed at Jim Walter Resources Inc., No. 4 mine. In a year about 1.13 million m^3 (40 MMcf) of methane was recovered from the coalbed.

OP 41–80. Completion Techniques and Production Data From Vertical Methane Drainage Boreholes, Jawbone Coalbed, Dickenson County, Virginia by Peter F. Steidl, Michael A. Trevits, and William P. Diamond. Pres. at SPE/DOE Symp. on Unconventional Gas Recovery, Pittsburgh, Pa., May 18–21, 1980, SPE Preprint 8965, pp. 325–328. Five vertical methane drainage boreholes have been completed in the Jawbone coalbed at the Clinchfield Coal Co. McClure No. 1 mine in Dickenson County, Va. Foam stimulation treatments were used to increase gas production from the boreholes. After 15 months the cumulative gas production from the first hole was 310,000 cu m (11 MMcf) with production averaging 700 cu m/d (25,000 cu ft/d).

OP 42–80. Determining the Feasibility of Using Vertical Boreholes to Drain Gas From the Pocahontos No. 3 Coalbed, Buchanan County, Va. by Michael A. Trevits, Walter L. Richards, and Hilmar A. Von Schonfeldt. Pres. at SPE/DOE Symp. on Unconventional Gas Recovery, Pittsburgh, Pa., May 18–21, 1980, SPE Preprint 8966, pp. 329–334. In July 1979, a project was established to determine the feasibility of using vertical boreholes to degasify the Pocahontas No. 3 coalbed in advance of mining. To date, three methane gas drainage boreholes have been completed near the Virginia Pocahontas No. 5 mine in Buchanan County, Va. Various coalbed reservoir tests and in situ stress determinations have been performed. Hydraulic stimulation treatments were designed and implemented at two boreholes, followed by preliminary gas and water production testing.

OP 43–80. Influence of Graphite Morphology on the Damping Properties of Selected Cast Iron Structures, by A. Visnapuu, B. A. Betts, and L. A. Neumeier. 37th Electric Furnace Conf. Proc., AIME, Detroit, Mich., Dec. 4–7, 1979; July 1980, pp. 304–306. Increasing attention has been directed toward a need for better structural materials to reduce equipment noise in metallurgical and other industries in compliance with imposed noise restrictions.

One of the goals of the Bureau of Mines is to minimize the undesirable environmental conflicts, impacts, and occupational hazards associated with mining and mineral processing operations. Toward this goal, the Bureau of Mines has investigated damping and other properties of experimental cast irons. It was shown that damping capacity and toughness intermediate to high-damping, brittle gray cast iron and low-damping, tough ductile cast iron can be installed in "hybrid" cast iron with a compacted graphite structure intermediate to the flakes of gray cast iron and the nodules of ductile iron. Damping capacity of ductile iron can also be enhanced by hot working reduction. Comparative damping data are given for hybrid cast iron, conventional gray and ductile cast irons, and steels containing various amounts of carbon and subjected to a variety of heat treatments.

OP 44–70. Oil Mining, by Richard A. Dick and Sheldon P. Wimpfen. Sci. Am., v. 243, No. 4, October 1980, pp. 156–161. Conventional drilling and pumping removes less than half of the oil in an average petroleum reservoir. As the price of oil rises, mining it underground or at the surface becomes economically more attractive. This report discusses the size of this potential resource and methods for its recovery.

OP 45–80. Diffraction Jig for Philips Electronics Diffractometers, by Charles W. Huggins and Stephen D. Cramer. Norelco Rep., v. 27, No. 1, April 1980, p. 40. An X-ray diffraction jig for use on Philips electronics diffractometers was designed and fabricated at the Avondale Research Center primarily for use on corrosion research using 3/8-in-diam metal electrodes that were covered with corrosion films and geothermal scales. The jig was constructed of an aluminum alloy and will handle a variety of sample sizes and shapes up to 1.5 by 2.0 cm. The jig dimensions and a sample illustration are given in the paper.

OP 46–80. Thermal Decomposition of Monomethylamine Nitrate, by Yael Miron. J. Hazardous Mater., Elsevier Scientific Publishing Co., Amsterdam, the Netherlands, v. 3, 1980, pp. 301–321. Monomethylamine nitrate (MMAN), was used during World War II as an ingredient for bomb and shell loading. Now it is used as a component in some water gel formations. Knowledge of its dissociation and/or decomposition mode would be desirable, but none was found in the open literature. MMAN decomposition was observed through differential scanning calorimetry, thermogravimetric analysis, and mass spectrometry. The effect of small amounts of iron oxide, rust, and copper on MMAN decomposition was also assessed. These compounds have shown catalytic activity in the decomposition of ammonium and hydrazine nitrates.

OP 47–80. The Bureau of Mines Shaft and Research Facility in the Oil Shales of Colorado, by Stephen Utter. Pres. at 83d National Western Min. Conf., Denver, Colo., Feb. 6–8, 1980; pub. in 1980 Mining Yearbook. Colorado Mining Association, Denver, June 1980, pp. 164–170. As part of a program to assess the environmental problems that would attend the mining of oil shale, the Bureau of Mines blind-bored a 10-ft-diam shaft to a depth of 2,371 feet in the Piceance Creek Basin and installed an 8-ft-diam steel casing to a depth of 2,352 feet. This pioneer shaft penetrates two aquifers, the rich Mahogany oil shale zone, and virtually the full thickness of oil shale and accessory minerals in the Parachute Creek member of the Green River Formation. A surface plant consisting of a headframe, hoist, and support facilities was erected, and the shaft was equipped with hoisting, ventilating, pumping, and service systems. Cutouts or windows were made in the shaft lining, and stations were opened on the 1,844- and 2,079-foot levels. A 10- by 10-foot entry was driven on the 2,079-foot level, and bulk samples of oil shale, dawsonite, and nahcolite were mined for processing tests. Problems with methane gas and ground water were encountered, and grouting was required.

OP 48–80. Environmental Assessment of an Oil Shale Installation, by Stephen Utter. Proc. 6th Ann. UMR-DNR Conf. on Energy, Rolla, Mo., Oct. 16–18, 1980, v. 6, pp. 481–485. The Bureau of Mines constructed a research facility in the oil shale deposits of the Piceance Creek Basin in northwestern Colorado. The purpose of the installation is to identify the environmental effects that could be expected from future commercial oil shale mines and to develop technology needed to resolve or mitigate environmental problems. This report describes the installation, outlines the research program for which the environmental assessment was made, and presents the findings of the assessment.

OP 49–80. W Recovery From Searles Lake by Ion Exchange, by P. B. Altringer and P. T. Brooks. Tungsten News, v. 18, No. 3, Summer 1980, pp. 3–4. An effective ion exchange operation to remove tungsten from Searles Lake brines using a pilot unit that has been operating since July 1979 at the Kerr-McGee Corp., Trona, Calif., is described. The extractive technique, developed by the Bureau of Mines, is based on a new tungsten-selective resin designated QRF. The objectives of the investigation includes (1) proving the operational viability during seasonal changes in brine properties, (2) providing a tungsten-rich solution to enable completion of tungsten recovery research, and (3) supplying data for system escalation to enable recovering nearly 227,000 kg per year of tungstic oxide.

OP 50–80. Theoretical Evaluation of Radon Emanation Under a Variety of Conditions, by John C. Edwards and Robert C. Bates. Health Phys., v. 39, August 1980, pp. 263–274. A cylindrical coordinate mathematical model to calculate ^{222}Rn flux and movement was developed considering ^{222}Rn production, decay, and diffusion in a multilayered, porous, permeable matrix. Air movement, transporting radon through the media, satisfies Darcy's law and is influenced by the air (barometric) pressure applied at the surface. Two zones of porous material have been defined, one with ^{222}Rn production term (the uranium ore zone) and the other without this term to simulate shotcrete or concrete ground support. A provision is made to evaluate the effect of a pinhole in an otherwise impermeable sealant. Comparisons are made between field measurements and predicted values. Specific examples are given of ^{222}Rn losses through pinholes for cases of linearly varying and static barometric pressures. The results suggest factors to consider in uranium mine radon control. For example, pinholes are not a serious problem since it appears that several thousand 2-mm-diam pinholes per square meter are required to cause a significant loss of a barrier coating's effectiveness.

OP 51–80. Consolidation of Industrial Clay Wastes, by B. J. Scheiner, J. R. Zatko, and A. G. Smelley. Proc. Environmental Symp. '80, New Orleans, La., Apr. 7–10, 1980, pp. 477–486. The Bu-

reau of Mines is developing a dewatering technique for phosphatic clay slime waste produced in Florida phosphate facilities. The technique consists of mixing the slime waste with a flocculant, polyethylene oxide, and dewatering the resulting agglomerate on a rotary screen. Slimes containing a nominal 3 wt-pct solids have been dewatered to solids contents of 20 to 30 pct. This paper describes a series of laboratory investigations applying the Bureau-developed dewatering technique to a variety of ultrafine waste materials.

OP 52–80. Thermodynamic Properties of $KAlO_2$, by R. P. Beyer, M. J. Ferrante, and R. R. Brown. J. Chem. Thermodynamics, v. 12, 1980, pp. 985–991. As part of a goal to advance mineral technology, to reduce energy use, and to abate pollution, the Bureau of Mines generates thermodynamic quantities on various minerals and metals. This study on potassium aluminate was undertaken to further this aim. Although of possible importance to the cement and ceramic industries, the current interest in potassium aluminate is its role in magnetohydrodynamic (MHD) power generation. Potassium, in the form of a seed material used to enhance the electrical conductivity of the high-temperature MHD generator plasma, reacts with alumina. Alumina is a major constituent of coal slag and a material of construction in MHD power generators. A better understanding of the potassium and alumina interaction will help with the problems of corrosion, seed material recycling, etc.

OP 53–80. Testing and Development of Materials for Catalytic Coal Gasification Process Equipment, by H. Heystek and N. S. Raymon. Proc. 5th Ann. Conf. on Materials for Coal Conversion and Utilization, Gaithersburg, Md., Oct. 7–9, 1980, pp. IV–1—IV–7. Catalytic coal gasification (CCG), one of the most promising third generation coal conversion processes, is based on reaction of coal and steam in the presence of an alkali metal catalyst to achieve high production of methane at a rate equivalent to second generation high British thermal unit process, but at lower temperatures and pressure. Additional advantages include reduced energy requirements, the elimination of a separate methanation reactor, and the ability to process caking coals. At present, few data are available to aid in selecting metal and refractory materials for reliable, low-cost services under the conditions prevailing in the CCG reactor itself. The objectives of this research are to determine the effect of CCG environments on metal and refractory materials of construction by exposure to CCG reactor conditions in a laboratory simulator and to identify the attack mechanisms of CCG environments on metals and refractories so that materials offering improved performance at lower cost can be identified.

OP 54–80. Retreatment of Tailings To Recover Barite, by W. E. Lamont, E. G. Davis, and G. V. Sullivan. Proc. 7th Miner. Waste Utilization Symp, Chicago, Ill., Oct. 20–21, 1980, pp. 26–33. The feasibility of recovering barite by retreatment of tailings was demonstrated in investigations by the Bureau of Mines. The investigation was part of the Bureau's program to conserve domestic mineral resources through advancing mineral resources technology. A primary objective was to produce concentrates that would be suitable for use in oil well drilling mud applications. Two samples of tailings were received from Nevada that represented the fine and very fine fractions of waste from an operating plant. Concentrates containing over 96 pct $BaSO_4$ were readily obtained from each. Barite recovery was 96 pct for the fine tailings and 86 pct for the very fine tailings. Treatment of a low-grade Missouri tailing by sizing and flotation resulted in a concentrate containing 96 pct $BaSO_4$ and an 86 pct recovery of the barite. A Georgia material responded in similar fashion with the concentrate containing 97 pct $BaSO_4$ and a barite recovery of 82 pct. All flotation concentrates had specific gravities in excess of the 4.20 specification for drill mud applications.

OP 55–80. Cobalt and Nickel Recovery From Missouri Lead Ores, by D. L. Paulson, W. M. Dressel, and R. M. Doerr. Proc. 7th Miner. Waste Utilization Symp., Chicago, Ill., Oct. 20–21, 1980, pp. 127–134. In its continuing effort to improve the utilization of domestic resources, the Bureau of Mines is developing procedures to recover up to 2.5 million pounds of cobalt and 3.5 million pounds of nickel lost annually in processing Missouri lead ores. The procedures include a physical method for producing a Co-Ni enriched product from a commercial lead mill Pb-Cu flotation rougher concentrate and a hydrometallurgical process for treating the enriched product and/or Co-Ni bearing lead smelter mattes and drosses. In the physical separation process, the Pb-Cu rougher concentrate is separated by wet high-intensity magnetic separation and the magnetic fraction (chalcopyrite concentrate) is reground and floated to produce a high-grade copper concentrate and a tailing product containing over 3.5 pct cobalt and 5 pct nickel. In the hydrometallurgical process, both the Co-Ni bearing tailing product and lead smelter mattes are leached with manganese dioxide and sulfuric acid to obtain cobalt, nickel, copper, lead, manganese sulfates, and elemental sulfur. At 85° to 100° C, the cobalt, nickel, and copper are solubilized as sulfates leaving a residue of $PbSO_4$, sulfur, and gangue. The residue can be returned to a smelter for lead recovery and the soluble metals are recovered from the leach solutions by caustic purification (removal of arsenic and iron) and sequential sulfide precipitations. The products are copper sulfide (62 pct copper) and Co-Ni sulfide (up to 50 pct combined cobalt and nickel). The manganese is reclaimed from the leach liquor as manganese oxide to be used for recycling.

OP 56–80. Surface Charge Heterogeneity in Amphibole Cleavage Fragments and Asbestos Fibers, by Joseph E. Schiller, Sequoyah L. Payne, and Sanaa E. Khalafalla. Pres. at ACS National Meeting, Washington, D.C., Sept. 9–14, 1979; pub. in Science, v. 209, Sept. 26, 1980, pp. 1530–1532. Aspect ratio and electrophoretic mobility data for amphibole particles reveal that short fibers and blocky cleavage fragments have a smaller net change than highly elongated particles. Asbestos fibers and cleavage fragments of the same dimensions exhibit the same net negative surface charge but positively charged ends and negatively charged lateral surfaces.

OP 57–80. Time-Dependent ^{222}Rn Samples Loss From Small Samples, by Robert C. Bates. Health Phys., v. 39, November 1980, pp. 799–801. A research plan was prepared to measure the effect of moisture on the ^{222}Rn emanation coefficient in small uranium ore samples. One version of the plan called for the sealed can to be counted after a long storage and then opened to let the free radon escape. However, a question arose about the information on many emanation coefficient measurements (for example, Ha36, Ki32, Sh70, St57, and Wa51). Reported values for ^{219}Rn, ^{220}Rn, and ^{222}Rn generally differ by

less than a factor of 10, which is considerably less than expected from linear diffusion theory (1, 3.7, 290, for ^{219}Rn, ^{220}Rn, and ^{222}Rn, respectively) (Ta78). This small difference suggests that radon escape is very rapid, and hence the steady-state flux might be reached within tens of seconds. None of the papers, however, specifically address the question; therefore, the Bureau of Mines performed the analytical study reported in this note.

OP 58–80. Challenges of the 1980's From the Perspective of the U.S. Bureau of Mines, by Ralph C. Kirby and Donald G. Kesterke. Proc. 8th Ann. Min. and Met. Div. Symp. and Exhibit, Phoenix, Ariz., May 14–16, 1980 (pub. as Instrumentation in the Mining and Metallurgy Industries), v. 7, pp. 19–26. This paper covers some of the underlying factors and forces that will shape the mining and metallurgical industries during the 1980's. The discussion includes what the Bureau of Mines plans to do about these forces and the Bureau's present reaction.

OP 59–80. Industrial Wastes, by S. L. Law. McGraw Hill Encyclopedia of Environmental Science. McGraw-Hill Book Co., Inc., New York, 2d. ed., 1980, pp. 387–396. Approximately 334 million metric tons of industrial processing residues are generated annually with 10 to 15 percent being classified as hazardous by the U.S. Environmental Protection Agency. Problems arising from improper disposal of these wastes are discussed along with several highly publicized examples including Love Canal in Niagara Falls, N.Y., and Valley of the Drums in Stump Gap Creek, Ky. Hazardous wastes are broken down by geographic regions and by industry. Waste waters and gaseous wastes are discussed as well as solid wastes. Sections on waste recycling, waste exchange, waste disposal options, and industrial discharges to publicly owned treatment works are included.

OP 60–80. Adapting Conventional Sputtering Equipment for Coating Long Tubes and Strips, by R. L. Lincoln and R. Blickensderfer. J. Vac. Sci. Technol., v. 17, No. 5, September–October, 1980, pp. 1252–1253. A method for adapting conventional sputtering equipment to coat long tubes and strips was devised at the Albany (Oreg.) Research Center, Bureau of Mines. This research was part of an effort to meet the Bureau's goal of minimizing the need for critical minerals through conservation, using coatings of metals applied by techniques such as sputtering, cladding, or surface alloying.

OP 61–80. Water Recovery and Disposal of Clay Waste Slimes, by B. J. Scheiner and A. G. Smelley. Proc. 1980 Symp. on Surface Mining Hydrology, Sedimentology and Reclamation, Lexington, Ky., Dec. 1–5, 1980, pp. 249–253. As part of research conducted in its mission to effect pollution abatement, the Bureau of Mines is developing a dewatering technique that allows for disposal of mineral wastes, for reuse of water now lost with these wastes, and for reclamation of mined land. The technique utilizes a high-molecular-weight nonionic polyethylene oxide polymer that has the ability to flocculate and dewater materials containing clay wastes. A variety of different clay wastes have been successfully dewatered in laboratory experiments. Coal-clay waste was consolidated from 4 to 57 wt-pct, potash-clay brine waste from 20 to 62 wt-pct, phosphatic-clay waste from 16 to 49 wt-pct, uranium mill tailings from 15 to 67 wt-pct, and talc tailings from 10 to 53 wt-pct. The consolidated materials can be handled by mechanical devices such as trucks and conveyors for disposal in mined-out areas.

OP 62–80. Contact Filtration of Asbestos Fibers With Magnesium Oxide, by Joseph E. Schiller and Sanaa E. Khalafalla. Pres. at 109th AIME Ann. Meeting, Las Vegas, Nev., Feb. 24–28, 1980, SME Preprint 80–108, pp. 1–7 As part of its research on identification of asbestos fibers, the Bureau of Mines discovered a method to remove asbestos fibers from water. The process and its theory of operation is described in this report. The surface charge of amphibole minerals in potable water was negative and, in common with most other silicate minerals, the isoelectric point of amphibole asbestos fibers is in the pH range 4 to 6. Magnesia is one of the rare oxides with a high isoelectric point of about 11. The surface of magnesium oxide will be positively charged in water at pH 6 to 8, while the electric charge on amphibole asbestos fibers is negative. Because of the electrical attraction of these oppositely charged solids, it was possible to remove negatively charged asbestos fibers by percolating water that contained suspended asbestos through a porous bed of magnesium oxide particles. Scanning electron photomicrographs indicated that essentially complete removal of the fibers was accomplished. Other materials tested as contact filter media and found to be effective or partially effective were sand, calcite, carbon, diatomaceous earth, and cellulose. Acidic aluminum collected amphibole fibers but not chrysotile fibers.

TECHNICAL PROGRESS REPORT

The following publication can be obtained from—

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TPR 110. Long-Term Response of a Coal Mine Roof to Time Lapse Between Exposure and Support, by Daryl E. Radcliffe and Raymond M. Stateham. 1980. 12 pp. 7 figs. The Bureau of Mines, as part of an agreement with the Bear Coal Co., Somerset, Colo., evaluated the response of a coal mine roof to time lapse. Time lapse, the interval between exposure and support of the roof, was studied using both instrumentation and statistics. Instrumentation studies were designed to equate displacement and rates of displacement with areas of roof left unsupported from 15 minutes to more than 4 days. A statistical study was completed to compare roof fall occurrence with time lapse intervals encountered during normal room-and-pillar mining. Results from this investigation show time lapse, in the Bear mine, to be insignificant with respect to roof stability after installation of permanent support.

INDEX OF BUREAU OF MINES PUBLICATIONS

ABBREVIATIONS

B	Bulletin
GS	Geological Survey
IC	Information Circular
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

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* MY 1978-79 (v. I)—Minerals Yearbook, Metals and Minerals, Volume I, 1978-79; MY 1978-79 (v. II)—Minerals Yearbook, Area Reports: Domestic, Volume II, 1978-79; MY 1978-79 (v. III)—Minerals Yearbook, Area Reports: International, Volume III, 1978-79.

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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.

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