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MINING AND MINERALS POLICY ACT OF 1970

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HEARING

BEFORE THE

SUBCOMMITTEE ON MINERALS, MATERIALS, AND FUELS

OF THE

COMMITTEE ON INTERIOR AND INSULAR AFFAIRS

UNITED STATES SENATE

NINETY-SECOND CONGRESS

FIRST SESSION

ON

S. 635

A BILL TO AMEND THE MINING AND MINERALS POLICY ACT
OF 1970

APRIL 28, 1971

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(II)

CONTENTS

	Page
S. 635.....	3
Public Law 91-631, S. 719.....	11
S. 1576.....	12

STATEMENTS

Allott, Hon. Gordon, a U.S. Senator from the State of Colorado.....	26
Bates, Dr. Thomas, vice president for planning, Pennsylvania State University, University Park, Pa.....	62
Beistline, Dr. Earl H., provost, University of Alaska.....	65
Bellmon, Hon. Henry, a U.S. Senator from the State of Oklahoma.....	37
Boyd, Dr. James, chairman of the board, Copper Range Co.....	39
Calhoun, John C., Jr., Texas A. & M. University.....	149
Elliott, Dr. John F., professor of metallurgy, Massachusetts Institute of Technology.....	123
Elliott, Dr. Martin A., corporate scientific adviser, Texas Eastern Transmission Corp., Houston, Tex.....	48
Falkie, Dr. Thomas V., head, Mineral Engineering Department, and chairman, mineral engineering management program, College of Earth and Mineral Sciences, the Pennsylvania State University.....	129
Haley, Ted D., associate professor of mining engineering, University of Kentucky.....	161
Hall, Dr. Newman A., executive director, Commission on Education, National Academy of Engineering.....	94
Hassialis, M.D., Krumb, professor of mining, Henry Krumb School of Mines—Columbia University.....	98
Haynes, Roger M., director, employee relations, Consolidation Coal Co.....	57
Heins, Dr. Robert W., professor, Department of Metallurgy and Mining Engineering, University of Wisconsin.....	159
Kent, Dr. James A., dean, College of Engineering, Michigan Technological University, Houghton, Mich.....	84
Lacy, Dr. Willard C., executive head, Department of Mining and Geological Engineering, University of Arizona.....	151
Lear, Dr. W. Edward, dean, School of Engineering, University of Alabama.....	142
Lucas, Dr. J. Richard, head, Department of Mining Engineering, Virginia Polytechnic Institute.....	145
Ludlum, Dr. John C., dean, the Graduate School, University of West Virginia, Morgantown.....	76
Lutz, Dr. Carl, dean of engineering, South Dakota School of Mines and Technology, Rapid City, S. Dak.....	86
Marzke, Dr. Oscar, vice president, United States Steel, Pittsburgh, Pa.....	45
McBride, Dr. Guy T., Jr. president, Colorado School of Mines.....	80
Morgan, Dr. John D., Jr., consultant, Daytona Beach, Fla.....	91
Morris, Thomas M., head, Department of Metallurgical Engineering, University of Arizona, past chairman of the council of education, AIME.....	158
Pask, Dr. Joseph A., assistant dean, College of Engineering, University of California at Berkeley.....	68
Pentecost, Dr. Joseph L., testifying for the National Institute of Ceramic Engineers, Columbus, Ohio.....	161
Planje, Dr. Theodore J., dean, School of Mines and Metallurgy, University of Missouri at Rolla.....	71
Randolph, Hon. Jennings, a U.S. Senator from the State of West Virginia.....	75
Reid, Dr. Rolland R., dean, College of Mines, University of Idaho.....	104
Richey, Herbert S., vice chairman of the board, National Coal Association, and president, Valley Camp Coal Co.....	52
Stahl, Dr. C. Drew, chairman, Petroleum Engineering Section, College of Earth and Mineral Sciences, the Pennsylvania State University, University Park, Pa.....	135
Wolf, Ernest N., president, Alaska Mines Association.....	78

IV

COMMUNICATIONS

	Page
Adamson, Dan K., assistant executive secretary, Society of Petroleum Engineers, Dallas, Tex.: Letter to Mr. Stahl, dated April 12, 1971.....	141
Bacon, Lloyd U., professor of geophysics, Michigan Technological University, Houghton, Mich.: Letter to Senator Allott, dated June 10, 1971...	35
Cole, David R., manager, Colorado Mining Assn., Denver, Colo.: Letter to Senator Allott, dated April 20, 1971.....	34
Freyberger, W. L., chairman, American Institute of Mining: Letter to Senator Allott, dated July 13, 1971.....	36
Colgate, Stirling A., president and director of research, New Mexico Institute of Mining and Technology, Socorro, N. Mex.: Letter to Senator Allott, dated April 26, 1971.....	36
Hayes, William C., State geologist and director, State of Missouri: Letter to Senator Allott, dated April 12, 1971.....	34
Mitchell, Lane, director of ceramic engineering, Georgia Institute of Technology: Telegram to Senator Allott, dated April 23, 1971.....	33
Scheid, Vernon E., dean and director, University of Nevada, Reno, Nev.: Letter to Senator Allott, dated April 23, 1971.....	35

ADDITIONAL INFORMATION

“Cost and Means of Financing Mineral Engineering Education,” by E. F. Osborn, Director, Bureau of Mines.....	30
Figure 1.—Steps in the utilization of mineral-based materials for commerce, mineral science, and technology.....	30
Figure 2.—Comparison of enrollment in mineral engineering and in comparable agriculture curriculums—Total of 2d-, 3d-, and 4th-year enrollments, Pennsylvania State University, fall 1969.....	31
“Future needs in education and research in material resource development”, by Rolland R. Reid, College of Mines, University of Idaho.....	106
“The Enrollment and Employment Problem of Mining”, by Professor M. D. Hassialis, Henry Krumb School of Mines, New York.....	101

APPENDIX

“A Proposed Policy for Mineral Resource Development in Engineering Schools,” report by the National Academy of Engineering, March 25–26, 1971.....	174
Boyle, W. A., president, United Mine Workers of America, statement of....	171
Gravel, Hon. Mike, a U.S. Senator from the State of Alaska.....	167
Haley, Ted D., director of the mining option of civil engineering, University of Kentucky.....	173
Johnson, A. William, dean, Graduate School, University of North Dakota...	173
Scheid, Vernon E., dean and director, Mackay School of Mines, University of Nevada.....	172
Smothers, William J., Ph. D., P.E., president, The American Ceramic Society, statement of.....	168

MINING AND MINERALS POLICY ACT OF 1970

WEDNESDAY, APRIL 28, 1971

UNITED STATES SENATE,
SUBCOMMITTEE ON MINERALS, MATERIALS AND FUELS,
OF THE COMMITTEE ON INTERIOR AND INSULAR AFFAIRS,
Washington, D.C.

The subcommittee met, pursuant to call, at 10 a.m., in room 3110, New Senate Office Building, Senator Moss, presiding.

Present: Senators Allott, Bellmon, Jordan of Idaho, Stevens, and Gravel.

Also present: Jerry T. Verkler, staff director; William J. Van Ness, Chief counsel; and Charles Cook, minority counsel.

Senator Moss. The hearing will come to order.

This is an open public hearing of the Subcommittee on Minerals, Materials and Fuels of the Interior Committee. We are here today to take testimony on S. 635, a bill that was introduced by Senator Allott, the ranking minority member of the Interior and Insular Affairs Committee, and cosponsored by a number of other Senators on the committee and other Senators, Western Senators who do not serve on the Interior Committee.

The bill is really a follow-on to the act which the Congress last year placed on the statute books to establish a national mining and minerals policy. This bill implements to some degree that policy by delineating how we should proceed to support, enhance and stimulate mining, minerals, metallurgicals, ceramics, fuels, scrap recycling, mine land preservation, mineral economics, and related environmental research and training of an adequate supply of scientists, engineers, and technicians in such fields by supporting the establishment of an appropriate research training center in each State.

This is a policy and practice that has been followed in other fields of involving the States, especially the educational institutions of the State in research and trying to coordinate it to support the research with the Federal contribution.

It is imperative, I think, that we maintain our mineral production. First of all so that we will not become more dependent on foreign sources for minerals, and in order to do that we must improve our technology and increase our domestic sources.

But at the same time, as all of us are so very acutely aware, we must be vigilant in the protection of our environment. The purpose of the legislation we are considering is to support and stimulate the research necessary to achieve the technology required by our increased demand for minerals and also by the environmental requirements associated with the production of these minerals.

In order to have a complete record I will direct that a copy of bill S. 635 and last year's bill which is now public law that bore the number S. 719 be printed, because I think these two are companion bills. Senator Mansfield has introduced a similar bill, similar to the Allott bill, and he intends to submit a statement which will go in the record in order that the matter may be considered before the committee at this time. I also direct a copy of the Mansfield bill, S. 1576, appear in the record.

(The documents referred to follow:)

92^D CONGRESS
1ST SESSION

S. 635

IN THE SENATE OF THE UNITED STATES

FEBRUARY 5 (legislative day, JANUARY 26), 1971

Mr. ALLOTT (for himself, Mr. BENNETT, Mr. BIBLE, Mr. DOMINICK, Mr. JACKSON, Mr. MOSS, and Mr. STEVENS) introduced the following bill; which was read twice and referred to the Committee on Interior and Insular Affairs

A BILL

To amend the Mining and Minerals Policy Act of 1970.

1 *Be it enacted by the Senate and House of Representa-*
2 *tives of the United States of America in Congress assembled,*
3 That the Mining and Minerals Policy Act of 1970 (84 Stat.
4 1876) is amended by adding at the end thereof the follow-
5 ing new sections:

6 “SEC. 3. It is the policy of Congress to support, en-
7 hance, and stimulate mining, mineral, metallurgical, ceramic,
8 fuel, scrap recycling, mined land reclamation, underground
9 reservoir utilization, mineral economics, and related environ-
10 mental research, and the training of an adequate supply of
11 scientists, engineers, and technicians in such fields, by sup-

1 porting the establishment of an appropriate research and
2 training center in each State.

3 "SEC. 4. (a) There are authorized to be appropriated to
4 the Secretary of the Interior for the fiscal year 1972 and each
5 subsequent year thereafter sums adequate to provide \$100,-
6 000 to each of the several States in the first year, \$150,000
7 in the second year, \$200,000 in the third year, and \$250,000
8 each year thereafter to assist each participating State in
9 establishing and carrying on the work of a competent and
10 qualified mining, minerals, and related environmental re-
11 search institute, center, or equivalent agency (hereinafter
12 referred to as 'institute') at one college or university in that
13 State, which college or university shall be the tax supported
14 school of mines or shall have a college or school of mines, or
15 if there be no college or school of mines or other tax sup-
16 ported college or university having a department of min-
17 ing and minerals, then it shall be a college or university
18 established in accordance with the Act approved July 2,
19 1862 (12 Stat. 503), as amended, entitled 'An Act donating
20 public lands to the several States and territories which may
21 provide colleges for the benefit of agriculture and the me-
22 chanic arts', or some other institution designated by act of
23 the legislature of the State concerned: *Provided*, That (1)
24 matching non-Federal funds at least equal to the Federal
25 share are used to support the institute; (2) if there is more

1 than one such college or university in a State, established in
2 accordance with said Act of July 2, 1862, funds under this
3 Act shall, in the absence of a designation to the contrary by
4 act of the legislature of the State, be paid to one such college
5 or university designated by the Governor of the State to
6 receive the same, subject to the Secretary's determination
7 that such college or university has, or may reasonably be
8 expected to have, the capability of doing effective work
9 under this Act; (3) two or more States may cooperate in
10 the designation of a single interstate or regional institute, in
11 which event the sums assignable to all of the cooperating
12 States shall be paid to such institute; and (4) a designated
13 college or university may, as authorized by appropriate State
14 authority, arrange with other colleges and universities within
15 the State to participate in the work of the institute.

16 “(b) It shall be the duty of each such institute to plan
17 and conduct or arrange for the conduct of competent re-
18 search, investigations, and experiments of either a basic or
19 practical nature, or both, in relation to mining, mineral,
20 metallurgical, ceramic, fuel, scrap recycling, mined land rec-
21 lamation, underground reservoir utilization, mineral eco-
22 nomics and related environmental research, and to provide
23 for the training of scientists, engineers, and technicians in
24 these fields. Such research, investigations, experiments, and
25 training may include, without being limited to, aspects of the

1 supply and demand for various minerals; conservation and
2 the best use of available supplies of minerals; health and
3 safety in mining; improved methods of mineral extraction
4 and exploration; mineral and mining economics; improved
5 methods of mineral production, extraction and exploration
6 which will reduce and minimize adverse effects upon the
7 environment; and legal, social, geographic, ecological, na-
8 tional defense, land use, and other considerations to help
9 assure satisfaction of the national needs and requirements,
10 in both the short and long term, for minerals and their prod-
11 ucts, having due regard to the avoidance of unnecessary and
12 unproductive duplication of research being conducted by
13 agencies of the Federal and State Governments or other
14 institutes receiving support under this Act.

15 "SEC. 5. (a) There is further authorized to be appro-
16 priated to the Secretary of the Interior for fiscal year 1972
17 and each subsequent year thereafter sums not in excess of
18 the following: 1972, \$1,000,000; 1973, \$2,000,000; 1974,
19 \$3,000,000; 1975, \$4,000,000; and 1976 and each suc-
20 ceeding fiscal year, \$5,000,000. Such moneys, when ap-
21 propriated, shall be available to meet the necessary expenses
22 of special mineral resource research projects which would
23 not otherwise be undertaken, and which the Secretary of the
24 Interior has identified as being of high priority in meeting
25 the objectives of this Act.

1 “(b) The Secretary shall, insofar as it is practicable,
2 utilize the facilities of institutes designated in section 4 of
3 this Act to perform such special research, authorized in sub-
4 section (a) hereof, and shall select the institute for the per-
5 formance of such special research on the basis of the qualifica-
6 tions of the personnel who will conduct and direct it, the
7 nature of the facilities available in relation to the particular
8 needs of the research project, special geographic, geologic,
9 or climatic conditions within the immediate vicinity of the
10 institute in relation to any special requirements of the research
11 project, and the extent to which it will provide opportunity
12 for training mineral resource scientists, engineers, and tech-
13 nicians.

14 “SEC. 6. To assure that any institute established under
15 this Act is adequately equipped to perform mineral resource
16 research and to train individuals in the mineral resource
17 fields, the Secretary of the Interior is authorized to make
18 grants to each institute to pay up to 75 per centum of the
19 cost of purchasing equipment, facilities, and library materials.
20 No portion of any such grant shall be applied to the acquisi-
21 tion by purchase or lease of any land or interests therein or
22 the rental, purchase, construction, preservation, or repair
23 of any building. There are hereby authorized to be appropri-
24 ated not to exceed \$5,000,000, annually, to remain available
25 until expended, to carry out the purposes of this section.

1 “SEC. 7. Sums available to the States under the terms
2 of sections 4, 5, and 6 of this Act shall be paid to their desig-
3 nated institutes at such times and in such amounts during
4 each fiscal year as determined by the Secretary of the In-
5 terior, and upon vouchers approved by him. Each institute
6 shall designate an officer appointed by its governing authority
7 who shall receive and account for all funds paid under the
8 provisions of this Act and shall make an annual report to
9 the Secretary of the Interior on or before the first day of
10 September of each year, on work accomplished and the status
11 of projects underway, together with a detailed statement
12 of the amounts received under any of the provisions of this
13 Act during the preceding fiscal year, and of its disbursement,
14 on schedules prescribed by the Secretary. If any of the
15 moneys received by the authorized receiving officer of any
16 institute under the provisions of this Act shall by action
17 or contingency be found by the Secretary to have been
18 improperly diminished, lost or misapplied, it shall be replaced
19 by the State concerned and until so replaced no subsequent
20 appropriation shall be allotted or paid to any institute of
21 such State.

22 “SEC. 8. No research, demonstration, or experiment
23 shall be carried out under this Act by an institute financed
24 by grants under this Act unless all uses, products, processes,
25 patents, and other developments resulting therefrom, with

1 such exception or limitation, if any, as the Secretary may
2 find necessary in the public interest, be available promptly
3 to the general public. There are authorized to be appropri-
4 ated such sums as are necessary for the printing and pub-
5 lishing of the results of activities carried out by institutes
6 under the provisions of this Act and for administrative plan-
7 ning and direction, but such appropriations shall not exceed
8 \$1,000,000 in any fiscal year.

9 "SEC. 9. The Secretary of the Interior is charged with
10 administration of this Act, and shall prescribe such rules and
11 regulations as may be necessary to carry out its provisions.
12 He shall furnish such advice and assistance as will best pro-
13 mote the purposes of this Act, participate in coordinating re-
14 search initiated under this Act by the institutes, encourage
15 and assist in the establishment and maintenance of coopera-
16 tion by and between the institute and between them and
17 other research organizations, the United States Department
18 of the Interior and other Federal establishments, and shall
19 act as a central clearinghouse for the results of research con-
20 ducted by the institutes.

21 "SEC. 10. The Secretary shall make an annual report
22 to the Congress of the receipts and expenditures and work
23 of the institutes in all States under the provisions of this Act.
24 His report shall indicate whether any portion of an appro-

1 priation available for allotment to any State has been with-
2 held and, if so, the reasons therefor.

3 "SEC. 11. Nothing in this Act shall be construed to im-
4 pair or modify the legal relation existing between any of the
5 colleges or universities under whose direction an institute is
6 established and the government of the State in which it is
7 located, and nothing in this Act shall in any way be con-
8 strued to authorize Federal control or direction of education
9 or training at any college or university.

10 "SEC. 12. As used in this Act, the term 'State' in-
11 cludes the Commonwealth of Puerto Rico."



Public Law 91-631
91st Congress, S. 719
December 31, 1970

An Act

84 STAT. 1876

To establish a national mining and minerals policy.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That this Act may be cited as the "Mining and Minerals Policy Act of 1970".

Mining and
Minerals Policy
Act of 1970.

Sec. 2. The Congress declares that it is the continuing policy of the Federal Government in the national interest to foster and encourage private enterprise in (1) the development of economically sound and stable domestic mining, minerals, metal and mineral reclamation industries, (2) the orderly and economic development of domestic mineral resources, reserves, and reclamation of metals and minerals to help assure satisfaction of industrial, security and environmental needs, (3) mining, mineral, and metallurgical research, including the use and recycling of scrap to promote the wise and efficient use of our natural and reclaimable mineral resources, and (4) the study and development of methods for the disposal, control, and reclamation of mineral waste products, and the reclamation of mined land, so as to lessen any adverse impact of mineral extraction and processing upon the physical environment that may result from mining or mineral activities.

For the purpose of this Act "minerals" shall include all minerals and mineral fuels including oil, gas, coal, oil shale and uranium. "Minerals."

It shall be the responsibility of the Secretary of the Interior to carry out this policy when exercising his authority under such programs as may be authorized by law other than this Act. For this purpose the Secretary of the Interior shall include in his annual report to the Congress a report on the state of the domestic mining, minerals, and mineral reclamation industries, including a statement of the trend in utilization and depletion of these resources, together with such recommendations for legislative programs as may be necessary to implement the policy of this Act.

Report to
Congress.

Approved December 31, 1970.

LEGISLATIVE HISTORY:

HOUSE REPORT No. 91-1442 (Comm. on Interior and Insular Affairs).

SENATE REPORT No. 91-390 (Comm. on Interior and Insular Affairs).

CONGRESSIONAL RECORD:

Vol. 115 (1969): Sept. 5, considered and passed Senate.

Vol. 116 (1970): Sept. 21, considered and passed House, amended.

Oct. 14, Dec. 18, Senate concurred in House amendments.

92^D CONGRESS
1ST SESSION

S. 1576

IN THE SENATE OF THE UNITED STATES

APRIL 20, 1971

Mr. MANSFIELD introduced the following bill; which was read twice and referred to the Committee on Interior and Insular Affairs

A BILL

To establish mining and mineral research centers, to promote a more adequate national program of mining and minerals research, to supplement the Act of December 31, 1970, and for other purposes.

1 *Be it enacted by the Senate and House of Representa-*
2 *tives of the United States of America in Congress assembled,*

3 That (a) this Act may be cited as the "Mining and Minerals
4 Resources Research Act of 1971".

5 (b) In recognition of the fact that the prosperity and
6 future welfare of the Nation is dependent in a large measure
7 on the sound exploration, extraction, processing, and de-

1 velopment of its unrenewable mineral resources, and in order
2 to supplement the Act of December 31, 1970, Public Law
3 91-631, commonly referred to as the Mining and Minerals
4 Policy Act of 1970, the Congress declares that it is the pur-
5 pose of this Act to stimulate, sponsor, provide for and/or
6 supplement present programs for the conduct of research,
7 investigations, experiments, demonstrations, exploration,
8 extraction, processing, development, production, and the
9 training of mineral engineers and scientists in the fields of
10 mining, mineral resources, and technology.

11 TITLE I—STATE MINING AND MINERAL
12 RESOURCES RESEARCH INSTITUTES

13 SEC. 100. (a) There are authorized to be appropriated
14 to the Secretary of the Interior for the fiscal year 1972,
15 and for each succeeding fiscal year thereafter the sum of
16 \$500,000 to assist each participating State in establishing
17 and carrying on the work of a competent and qualified
18 mining and mineral resources research institute, center, or
19 equivalent agency (hereinafter referred to as "institute")
20 at one college or university in that State, which college or
21 university shall be a college or university established in
22 accordance with the Act approved July 2, 1862 (12 Stat.
23 503), entitled "An Act donating public lands to the several
24 States and Territories which may provide colleges for the
25 benefit of agriculture and the mechanic arts" or some other

1 institution designated by Act of the legislature of the State
2 concerned: *Provided*, That (1) such moneys when appro-
3 priated shall be made available to match, on a dollar for
4 dollar basis, non-Federal funds which shall be at least equal
5 to the Federal share to support the institute; (2) if there
6 is more than one such college or university in a State, es-
7 tablished in accordance with said Act of July 2, 1862, funds
8 under this Act shall, in the absence of a designation to the
9 contrary by act of the legislature of the State, be paid to
10 the one such college or university designated by the Gover-
11 nor of the State to receive the same subject to the Secre-
12 tary's determination that such college or university has, or
13 many reasonably be expected to have, the capability of
14 doing effective work under this Act; (3) two or more
15 States may cooperate in the designation of a single inter-
16 state or regional institute, in which event the sums assign-
17 able to all of the cooperating States shall be paid to such
18 institute; and (4) a designated college or university may,
19 as authorized by appropriate State authority, arrange with
20 other colleges and universities within the State to participate
21 in the work of the institute.

22 (b) It shall be the duty of each such institute to plan
23 and conduct and/or arrange for a component or components
24 of the college or university with which it is affiliated to con-
25 duct competent research, investigations, demonstrations, and

1 experiments of either a basic or practical nature, or both, in
2 relation to mining and mineral resources and to provide for
3 the training of mineral engineers and scientists through such
4 research, investigations, demonstrations, and experiments.
5 Such research, investigations, demonstrations, experiments,
6 and training may include, without being limited to, explora-
7 tion; extraction; processing; development; production of
8 mineral resources; mining and mineral technology; supply
9 and demand for minerals; conservation and best use of avail-
10 able supplies of minerals; the economic, legal, social engineer-
11 ing, recreational, biological, geographic, ecological, and other
12 aspects of mining, mineral resources, and mineral reclama-
13 tion, having due regard to the interrelation on the natural
14 environment, the varying conditions and needs of the respec-
15 tive States, to mining and mineral resource research projects
16 being conducted by agencies of the Federal and State gov-
17 ernments, and others, and to avoid any undue displacement
18 of mineral engineers and scientists elsewhere engaged in min-
19 ing and mineral resources research.

20 SEC. 101. (a) There is further authorized to be appro-
21 priated to the Secretary of the Interior for fiscal year 1972,
22 and the four succeeding fiscal years thereafter the sum of
23 \$5,000,000 annually, which shall remain available until
24 expended. Such moneys when appropriated shall be made
25 available to institutes to meet the necessary expenses of spe-

1 cific mineral research and demonstration projects of indus-
2 trywide application, which could not otherwise be under-
3 taken, including the expenses of planning and coordinating
4 regional mining and mineral resources research projects by
5 two or more institutes.

6 (b) Each application for a grant pursuant to subsection
7 (a) of this section shall, among other things, state the
8 nature of the project to be undertaken, the period during
9 which it will be pursued, the qualifications of the personnel
10 who will direct and conduct it, the estimated cost, the im-
11 portance of the project to the Nation, region, or State con-
12 cerned, and its relation to other known research projects
13 theretofore pursued or being pursued, and the extent to
14 which it will provide opportunity for the training of mining
15 and mineral engineers and scientists, and the extent of par-
16 ticipation by nongovernmental sources in the project. No
17 grant shall be made under said subsection (a) except for
18 a project approved by the Secretary of the Interior, and all
19 grants shall be made upon the basis of merit of the project,
20 the need for the knowledge which it is expected to produce
21 when completed, and the opportunity it provides for the
22 training of individuals as mineral engineers and scientists.

23 SEC. 102. Sums available to the States under the terms
24 of sections 100 and 101 of this Act shall be paid to their
25 designated institutes at such times and in such amounts dur-

1 ing each fiscal year as determined by the Secretary, and upon
2 vouchers approved by him. The Secretary may designate
3 a certain proportion of the funds authorized by section 100 of
4 this Act for scholarships, graduate fellowships, and post-
5 doctoral fellowships. Each institute shall set forth its plan to
6 provide for the training of individuals as mineral engineers
7 and scientists under a curriculum appropriate to the field of
8 mineral resources and mineral engineering and related fields;
9 set forth policies and procedures which assure that Federal
10 funds made available under this title for any fiscal year will
11 supplement and, to the extent practicable, increase the level
12 of funds that would, in the absence of such Federal funds,
13 be made available for purposes of this title, and in no case
14 supplant such funds; have an officer appointed by its govern-
15 ing authority who shall receive and account for all funds paid
16 under the provisions of this Act and shall make an annual
17 report to the Secretary on or before the 1st day of Septem-
18 ber of each year, on work accomplished and the status of
19 projects underway, together with a detailed statement of the
20 amounts received under any provisions of this Act during the
21 preceding fiscal year, and of its disbursements on schedules
22 prescribed by the Secretary. If any of the moneys received
23 by the authorized receiving officer of any institute under the
24 provisions of this Act shall by any action or contingency
25 be found by the Secretary to have been improperly dimin-

1 ished, lost, or misapplied, it shall be replaced by the State
2 concerned and until so replaced no subsequent appropriation
3 shall be allotted or paid to any institute of such State.

4 SEC. 103. Moneys appropriated pursuant to this Act, in
5 addition to being available for expenses for research; investi-
6 gations, experiments, and training conducted under authority
7 of this Act, shall also be available for printing and publishing
8 the results thereof and for administrative planning and direc-
9 tion. The institutes are hereby authorized and encouraged to
10 plan and conduct programs under this Act in cooperation
11 with each other and with such other agencies and individuals
12 as may contribute to the selection of the mining and mineral
13 resources problems involved, and moneys appropriated pur-
14 suant to this Act shall be available for paying the necessary
15 expenses of planning, coordinating, and conducting such
16 cooperative research.

17 SEC. 104. The Secretary of the Interior is hereby
18 charged with the responsibility for the proper administration
19 of this Act and, after full consultation with other interested
20 Federal agencies, shall prescribe such rules and regulations as
21 may be necessary to carry out its provisions. The Secretary
22 shall require a showing that institutes designated to receive
23 funds have, or may reasonably be expected to have, the capa-
24 bility of doing effective work. The Secretary shall furnish
25 such advice and assistance as will best promote the purposes.

1 of this Act, participate in coordinating research initiated
2 under this Act by the institutes, indicate to them such lines of
3 inquiry as to him seem most important, and encourage and
4 assist in the establishment and maintenance of cooperation by
5 and between the institutes and between them and other re-
6 search organizations, the United States Department of the
7 Interior, and other Federal establishments.

8 On or before the 1st day of July in each year after the
9 passage of this Act, the Secretary shall ascertain whether the
10 requirements of section 102 have been met as to each State,
11 whether it is entitled to receive its share of the annual appro-
12 priations for mining and mineral resources research under
13 section 100 of this Act, and the amount which it is entitled to
14 receive.

15 The Secretary shall make an annual report to the Con-
16 gress of the receipts, expenditures, and work of the institutes
17 in all States under the provisions of this Act. The Secretary's
18 report shall indicate whether any portion of an appropriation
19 available for allotment to any State has been withheld and,
20 if so, the reasons therefor.

21 SEC. 105. Nothing in this Act shall be construed to im-
22 pair or modify the legal relationship existing between any of
23 the colleges or universities under whose direction an institute
24 is established and the government of the State in which it is
25 located, and nothing in this Act shall in any way be con-

1 stried to authorize Federal control or direction of educa-
2 tion at any college or university.

3 TITLE II—ADDITIONAL MINING AND MINERAL
4 RESOURCES RESEARCH PROGRAMS

5 SEC. 200. There is authorized to be appropriated to the
6 Secretary of the Interior \$10,000,000 in fiscal year 1972,
7 increasing \$2,000,000 annually for five years, and continuing
8 at \$20,000,000 annually thereafter from which the Secretary
9 may make grants, contracts, matching, or other arrange-
10 ments with educational institutions; private foundations or
11 other institutions with private firms and individuals; and
12 with local, State, and Federal Government agencies, to under-
13 take research into any aspects of mining and mineral re-
14 sources problems related to the mission of the Department
15 of the Interior, which may be deemed desirable and are not
16 otherwise being studied. The Secretary shall, insofar as it is
17 practicable utilize the facilities of institutes designated in sec-
18 tion 100 of this Act to perform such special research, author-
19 ized by this section, and shall select the institutes for the per-
20 formance of such special research on the basis of the qualifica-
21 tions of the personnel who will conduct and direct it, the
22 nature of the facilities available in relation to the particular
23 needs of the research project, special geographic, geologic, or
24 climatic conditions within the immediate vicinity of the in-
25 stitute in relation to any special requirements of the research

1 project, and the extent to which it will provide opportunity
2 for training individuals as mineral engineers and scientists.

3 TITLE III—MISCELLANEOUS PROVISIONS

4 SEC. 300. The Secretary of the Interior shall obtain the
5 continuing advice and cooperation of all agencies of the
6 Federal Government concerned with mining and mineral re-
7 sources of State and local governments, and of private insti-
8 tutions and individuals, to assure that the programs
9 authorized in this Act will supplement and not duplicate
10 established mining and minerals research programs, to stimu-
11 late research in otherwise neglected areas, and to contribute
12 to a comprehensive, nationwide program of mining and
13 minerals research. The Secretary shall make generally avail-
14 able information and reports on projects completed, in
15 progress, or planned under the provisions of this Act, in
16 addition to any direct publication of information by the in-
17 stitutes themselves.

18 SEC. 301. Nothing in this Act is intended to give or
19 shall be construed as giving the Secretary of the Interior
20 any authority or surveillance over mining and mineral re-
21 sources research conducted by any other agency of the Fed-
22 eral Government, or as repealing, superseding, or diminishing
23 existing authorities or responsibilities of any agency of the
24 Federal Government to plan and conduct, contract for, or
25 assist in research in its area of responsibility and concern
26 with mining and mineral resources.

1 SEC. 302. Contracts or other arrangements for mining
2 and mineral resources research work authorized under this
3 Act with an institute, educational institution, or nonprofit
4 organization may be undertaken without regard to the provi-
5 sions of section 3684 of the Revised Statutes (31 U.S.C.
6 529) when, in the judgment of the Secretary of the Interior,
7 advance payments of initial expense are necessary to facili-
8 tate such work.

9 SEC. 303. No part of any appropriated funds may be
10 expended pursuant to authorization given by this Act for
11 any scientific or technological research or development activ-
12 ity unless such expenditure is conditioned upon provisions
13 determined by the Secretary of the Interior, with the ap-
14 proval of the Attorney General, to be effective to insure that
15 all information, uses, products, processes, patents, and other
16 developments resulting from that activity will (with such
17 exception and limitation as the Secretary may determine,
18 after consultation with the Secretary of Defense, to be neces-
19 sary in the interest of the national defense) be made freely
20 and fully available to the general public. Nothing contained
21 in this section shall deprive the owner of any background
22 patent relating to any such activity of any rights which that
23 owner may have under that patent.

24 SEC. 304. There shall be established, in such agency and
25 location as the President determines to be desirable, a center

1 for cataloging current and projected scientific research in all
2 fields of mining and mineral resources. Each Federal agency
3 doing mining and mineral resources research shall cooperate
4 by providing the cataloging center with information on work
5 underway or scheduled by it. The cataloging center shall
6 classify and maintain for general use a catalog of mining and
7 mineral resources research and investigation projects in prog-
8 ress or scheduled by all Federal agencies and by such non-
9 Federal agencies of government, colleges, universities,
10 private institutions, firms, and individuals as voluntarily may
11 make such information available.

12 SEC. 305. The President shall, by such means as he
13 deems appropriate, clarify agency responsibility for Federal
14 mining and mineral resources research and provide for inter-
15 agency coordination of such research, including the research
16 authorized by this Act. Such coordination shall include (a)
17 continuing review of the adequacy of the Government-wide
18 program in mining and mineral resources research, (b)
19 identification and elimination of duplication and overlap
20 between two or more agency programs, (c) identification
21 of technical needs in various mining and mineral resources
22 research categories, (d) recommendations with respect to
23 allocation of technical effort among the Federal agencies, (e)
24 review of technical manpower needs and findings concerning
25 management policies to improve the quality of the Govern-

1 ment-wide research effort, and (f) actions to facilitate inter-
2 agency communication at management levels.

3 SEC. 306. (a) The Secretary of the Interior shall ap-
4 point an Advisory Committee on Mining and Minerals Re-
5 sources Research composed of—

6 (1) the Director, Bureau of Mines, or his delegate,
7 with his consent;

8 (2) the Director of the National Science Founda-
9 tion, or his delegate, with his consent;

10 (3) the President, National Academy of Sciences,
11 or his delegate, with his consent;

12 (4) the President, National Academy of Engineer-
13 ing, or his delegate, with his consent; and

14 (5) such other persons as the Secretary may ap-
15 point who are knowledgeable in the field of mining and
16 mineral resources research.

17 (b) The Secretary shall designate the Chairman of the
18 Advisory Committee. The Advisory Committee shall consult
19 with, and make recommendations to, the Secretary of the In-
20 terior on all matters involving or relating to mining and
21 mineral resources research. The Secretary of the Interior
22 shall consult with, and consider recommendations of, such
23 Committee in the conduct of mining and mineral resources
24 research and the making of any grant under this Act.

25 (c) Advisory Committee members, other than officers or

1 employees of Federal, State, or local governments, shall be,
2 for each day (including traveltime) during which they are
3 performing Committee business, entitled to receive compen-
4 sation at a rate fixed by the appropriate Secretary but not in
5 excess of the maximum rate of pay for grade GS-18 as
6 provided in the General Schedule under section 5332 of title
7 5 of the United States Code, and shall, notwithstanding the
8 limitations of sections 5703 and 5704 of title 5 of the United
9 States Code, be fully reimbursed for travel, subsistence, and
10 related expenses.

Senator Moss. We had hoped this morning and expected to have testimony from the Assistant Secretary of the Interior for Mineral Resources and from the Director of the Bureau of Mines. However, just this morning a letter was delivered here to the committee addressed to Senator Jackson which reads as follows:

The Subcommittee on Mines, Minerals, and Fuels has requested this Department to appear and testify on the Mining and Minerals Policy Act introduced as S. 635 on April 28, 1971. Unfortunately we have not been able to arrive at an Administration position on this legislation and therefore respectfully request that you postpone our appearance for 30 to 60 days. During this time we will endeavor to formulate our position on this legislative proposal.

It is signed by Hollis M. Dole, Assistant Secretary of the Interior. Naturally we are very greatly disappointed in receiving this news and just receiving it this morning when so many of you other witnesses have traveled long distances to make your appearance before this subcommittee.

We apologize for the inconvenience that may have been imposed on some of you who are entitled to hear what the administration position would be on the bill and it might make your testimony different in some respect in responding to whatever the administration would report.

It is a disappointment to us but we do want to go ahead anyway and make our record as full as we can because this subcommittee and the entire committee are anxious to move on in what we consider a very important field. In fact, we think it is imperative that something be done now to implement the policy which the Congress adopted last year on mineral research and production in this country.

So we will hear the witnesses. We have a great many and very distinguished witnesses. In fact, there are so many I am going to have to ask you to be as brief as possible and wherever possible submit your written text rather than read the matter in its entirety so that we may compress into this 1 day's time all of the information we want to get into the record.

As I said in the opening, the principal author of this bill as well as the one we passed last year is the senior Senator from Colorado, Senator Allott, who is the ranking minority member on the full committee and I am going to call on Senator Allott for any comments he has to make at this time before we call the first panel of witnesses.

STATEMENT OF HON. GORDON ALLOTT, A U.S. SENATOR FROM THE STATE OF COLORADO

Senator ALLOTT. Thank you very much, Mr. Chairman. Before making my statement I would like to do three things. First of all, express my appreciation to all of you who have appeared here today to participate in these hearings. Secondly, I think the chairman deserves a great deal of credit, he was the coauthor of the original minerals policy bill as well as the bill S. 635 on which we are holding this hearing on this morning.

The third thing I would like to say this morning is that unfortunately I find myself with five committee hearings scheduled this morning, all of which will demand my presence at least a portion of the time. I will spend as much time in here as I can in between those hearings.

Lastly, I would like to say this: The form of S. 635 was developed

to a large extent out of the remarkable and outstanding testimony that we had for the original National Minerals Policy Act in which many of you participated.

Among those who participated enthusiastically was the President's Assistant Secretary of Interior, Hollis Dole, and Dr. Osborn, who was at Penn State and who was one of its most enthusiastic supporters and who, you will recall, developed some very, very progressive, substantive, and objective ideas as to what the original bill might have done.

I am sorry, too, that they cannot be here, because I know, and if you will refer to the record which was made in this room on the original national minerals policy bill, you all know very well the personal feelings that Dr. Osborn and Hollis Dole had on this particular matter. Unfortunately, I think the problem lies in the Office of Management and Budget, which sometimes has a hard time making up its mind what it is going to do.

Nearly 2 years ago we held hearings before this same subcommittee on the legislation to establish a national mining and minerals policy. I am gratified that the legislation is now the law of the land. The National Mining and Minerals Policy Act was intended to be a cornerstone on which we could build a national program to insure the availability of mineral commodities necessary to supply our industry and provide for our national security.

Population growth and increasing per capita mineral demands are placing unprecedented demands on the Nation's natural resources. Recent experience has taught us dependence on foreign sources tends to encumber our foreign policy and limit our freedom of movement in the family of nations.

It is in the long term national interest that our ability to domestically produce important mineral commodities be improved. The best hope for achieving this objective is through technological advances in methods of finding, mining, and processing available resources.

Radically new approaches may be necessary to achieve this and research is the logical path to new technology. Our continued progress depends upon it. S. 635 addresses itself to the development and application of the new technology necessarily depends upon attracting and training scientists, engineers, and technicians, it is also the purpose of the bill to aid in the training of qualified personnel through the establishment of research centers.

The challenge to the men of the minerals industry is great, and lesser men would shrink from it. Our minerals men must not only continue to supply the Nation's enormous appetite for mineral commodities, but they must do it without doing permanent violence to the environment and with as little temporary disruption as is practical.

In addition, the ores are becoming leaner and future discoveries of major ore bodies are likely to be deeper and therefore new technology is necessary to the successful mining and extraction of mineral commodities. Virtually no mineral deposits will economically yield all of their values and many will give up only 50 percent of their values with present technology.

Recycling is an essential element to the wide use of our natural resources since it extends the life of a mineral commodity. But it also applies to the land resource from which the commodity was extracted. Land reclamation is an essential part of the new environmental challenge to the minerals industry.

But perhaps our thinking with respect to land reclamation has been in a much too narrow frame of reference. It is a part of recycling, by that I mean as an ore body is mined out the area must be restored to useful condition. In other words, a second use. Too often land reclamation is viewed as a requirement to restore the mined land to nearly its identical condition just prior to mining. This may not be the best second use of the land. This land may very well be far more useful, with some modifications, in its mined-out condition and I must say, Mr. Chairman, that I am now working on a presentation with respect to this that I hope to make and complete in the next few weeks to this committee which I think will be a very challenging presentation.

Senator MOSS. We would be glad to have that and we will include it in the record since obviously we will hold this record open until we hear from the Department of the Interior.

Senator ALLOTT. As an example of this, gravel pits are ordinarily close to metropolitan areas, this is due to the cost of hauling. Since petroleum bulk supply depots must be close to the metropolitan area they serve perhaps, a better second use of the gravel pit would be as a tank farm.

Safety precautions require dikes be built around the tank farm so the spillage does not escape. In the case of a worked-out pit much of the excavation is already accomplished. In other instances, worked-out underground mines may serve as subterranean warehouses and loading terminals providing the location and other factors are appropriate.

These examples are only two possibilities that I mention simply to show that with the technology, ingenuity, and opportunity many of our environmental problems could, with some exercise of forethought and foresight, become solutions for other problems.

It is hoped that S. 635 will help the minerals industry and Nation deal effectively with all of these and other related programs and problems not mentioned. But let no one be confused, S. 635 is a long-range program and to expect instant solutions is to be misled.

Significant impact of the bill will most likely not occur until after the passage of at least 10 years. But it seems obvious that the benefits of the program to be established by this bill will be even more important to the social, economic, and environmental well-being of the Nation in the next decade.

The purpose and policy of the legislation is set forth in the first section and that is the proposed new section 3 of the Mining and Minerals Policy Act of 1970. It states:

It is the policy of Congress to support, enhance and stimulate mining, mineral, metallurgical, ceramic, fuels, scrap recycling, mine land reclamations, underground reservoir, mineral economics and related environmental research and the training of an adequate supply of scientists, engineers and technicians in such areas by supporting the establishment of an appropriate research and training center in each state.

Under the provisions of section 4 each State could establish an institute or research center in one of its tax-supported colleges or universities, preferably its school of mines or its college or university having a department of mining, mining engineering, and metallurgy.

The grants would be on a matching basis requiring at least half the support to come from non-Federal funds. Each State is eligible provided it meets the requirements of the act. As pointed out in the hearings on S. 719 in 1969 by Dr. Elbert Osborn,

Every state has important essential mineral resources, sand, gravel, building stone, industrial minerals, et cetera, and in addition may have one or more metallic ores, petroleum, natural gas or coal.

Section 5 authorizes special mineral research projects to be conducted under the direction of the Secretary of the Interior. These projects would be of high priority to meet certain urgent needs and would normally be conducted by the institutes established under section 4 of this act.

In order to assist the States establishing a research institute, section 6 provides for grants of up to 75 percent of the cost of purchasing equipment, facilities, and library materials. None of this money can be used for providing buildings or land.

Section 7 provides for an annual report to the Secretary and other housekeeping measures. Section 8 requires that the results of all research conducted under this act and financed by the Federal Government under this act shall be promptly available to the general public.

It also provides for the publishing and printing of research results. The purpose here is to insure that new technology and improved methods are made available to the mineral industry at the earliest possible date, and, where applicable, they may be employed as widely as possible.

Section 9 places the Secretary of the Interior in charge of the program and gives him the responsibility for coordinating research and maintaining cooperation between the institutes, Federal research organization and other research establishments.

The Secretary shall be also act as a central clearinghouse for the results of such research. Section 10 provides for the annual report to the Congress by the Secretary. Section 11 prevents the act from impairing or modifying the legal relationship between the college and university and the State.

Section 12 includes Puerto Rico within the definition of "State." The maximum appropriation authorized under this bill would be \$23,750,000, after the fifth year, but that small investment can yield benefits many times as great to the Nation.

Mr. Chairman, I would be remiss if I did not recognize the bipartisan support and cosponsorship of S. 635. For the sake of the record I would like to mention in alphabetical order those distinguished Senators who joined me in sponsoring this measure.

Senators Bennett, Bible, Dominick, Fannin, Jackson, Jordan, Mansfield, Moss, and Stevens. This interest is especially gratifying since no formal letter of request for cosponsors was ever made from my office. One final point, Mr. Chairman, our second governmental witness, Dr. Elbert F. Osborn, Director of the Bureau of Mines, is deserving a special recognition with respect to this legislation since it was the work of the Committee on Mineral Science and Technology of the National Academy of Sciences, under his able chairmanship, which provided the in-depth supporting evidence of the need for this legislation.

In 1969, the Osborn committee made a number of significant recommendations, some of which have been enacted into law as a part of the Mining and Minerals Act of 1970. I shall quote two of these recommendations which relate to the legislation before us, "A program be established under the Assistant Secretary for Mineral

Resources to provide continuing federally appropriated matching funds to each State in support of mineral resource research.

"The Bureau of Mines develop sustaining research and educational programs in mineral science, technology, and engineering through grants, contracts, and traineeships at educational institutions."

Mr. Chairman, we have a distinguished list of witnesses and I know their testimony will be highly instructive and I look forward to hearing it with great interest.

In conclusion, I know I do not have to convince the members of this committee nor those present of the critical situation and the need for legislation of this sort. It seems to me our job is to make such a strong case here that we can convince the rest of the country and perhaps even the Office of Management and Budget. [Laughter.]

Senator Moss. Thank you, Senator Allott, for that fine opening statement and analysis of the provisions of the bill. We are glad to have that in the record.

(The program referred to by Senator Allott follows.)

COST AND MEANS OF FINANCING MINERAL ENGINEERING EDUCATION

(By E. F. Osborn)

I have been asked to talk about the cost and financing of mineral engineering education. Perhaps more in keeping with the national situation would be a talk on the high cost to the nation of our neglect of proper financing of mineral engineering education. Many of our more dismal headlines relate to mineral resources problems—headlines about mine disasters, oil spills, acid mine water, air pollution, and so on. These spectacular troubles are only a part of the serious difficulties that we find engulfing the mineral industries; and these difficulties are related to the almost unbelievable neglect in universities of mineral engineering education.

The mineral engineering fields are those that have to do with the extraction and primary production of mineral resources, and in general with use of the underground. The mineral engineering fields in universities are essentially synonymous with the fields which our recent National Academy committee report¹ referred to as mineral science and technology. The spectrum of these and related fields is shown on the first slide. We do not include the geological sciences on the left, but would include geological engineering; and do not include most of what is known as materials science and solid state physics on the far right. The fields as popularly known therefore are mining, mineral processing, extractive metallurgy, ceramics, fuel science and engineering, geological engineering, and I would also include mineral economics.

FIGURE 1.—STEPS IN THE UTILIZATION OF MINERAL-BASED MATERIALS FOR COMMERCE, MINERAL SCIENCE, AND TECHNOLOGY

Geological sciences			Materials science		
I	II	III	IV	V	VI
Exploration	Production of raw materials.	Beneficiation of raw materials.	Extraction and production of metals. Primary processing of minerals for nonmetallic uses. Processing and conversion of fuels.	Fabrication of materials with specific composition and structure.	Properties and uses of materials.

¹"Mineral Science and Technology: Needs, Challenges and Opportunities." A report by the Committee on Mineral Science and Technology of the National Academy of Sciences—National Academy of Engineering—National Research Council, Washington, D.C., 1969.

FIGURE 2—COMPARISON OF ENROLLMENT IN MINERAL ENGINEERING AND IN COMPARABLE AGRICULTURE CURRICULUMS—TOTAL OF 2d-, 3d-, AND 4th-YEAR ENROLLMENTS, PENNSYLVANIA STATE UNIVERSITY, FALL 1969

Curriculum	Enrollment	Curriculum	Enrollment
Ceramic science.....	37	Wood science.....	10
Fuel science.....	10	Food science.....	5
Mining engineering.....	30	Agricultural engineering.....	30
Metallurgy.....	43	Horticulture.....	44
Petroleum and natural gas.....	45	Agronomy.....	43
Mining economics.....	54	Agricultural economics.....	26

The problems associated with mineral production must certainly be quite well known to this group. Included among these, and very obvious to the public are those for example that have to do with coal mining. In my state of Pennsylvania we have almost unbelievably extensive pollution of streams by acid water draining from abandoned coal mines. About 40 of these mines are burning underground and in some cases the surface is subsiding and cracks opening. The lack of adequate technology in mining seems matched in the petroleum production industry where we are told we can expect oil spill disasters on an annual basis.

Then there is the serious matter of meeting our ever increasing requirements for mineral products, as other nations are becoming more industrialized and are competing for the same materials. Alarming is the fact that to meet the nation's increasing mineral products requirements, we depend more and more on foreign sources many of which cannot be considered as reliable long range sources. The net value of mineral imports over exports has tripled in the last decade; in 1966 imports were valued at 6.7 billion dollars and exports at 3.4 billion dollars. I believe that it is mainly the technology that we are running out of in America rather than mineral resources.

Mineral engineers not only deal with mineral production but are involved in every type of use of the continental crust. They have the knowledge and experience with respect to the underground "environment", and as engineers must be held responsible for the wise use of the underground. This responsibility is becoming more and more important as we increasingly use the underground for storage and disposal of materials of all kinds: solids, liquids, and gases. Such use must be on a planned basis, regionally as well as locally, to avoid serious contamination and at the same time to make maximum use of the underground. Yet the knowledge needed for this planning is not available nor is it in the process of being obtained on the scale needed.

The threat of serious pollution of the underground, jeopardizing future water supplies or the use of underground zones for other purposes in the future, is from many sources, but principally from: (1) The leachate draining into the underground water system from landfill garbage and trash disposal operations, (2) Poisonous fluids being injected under high pressure into underground zones, escaping and possibly causing widespread crustal contamination, and even causing surface pollution as these fluids more and more frequently are found to be erupting at the surface, (3) Radioactive wastes which are increasing rapidly in amount and are being buried in some cases without the thorough knowledge of the geology required for the full and needed assessment of the safety factors involved, (4) Leakage from buried storage tanks and pipe lines, contaminating drinking water supplies and even seeping into basements of homes.

At the same time we have a national crisis on our hands because of mineral resource problems and underground pollution dangers, it is an almost incredible fact that the very fields of university education and research dealing with these problems are being phased out at our education institutions. With a little thought on the situation, one realizes that there is a connection. Without the basic education and research, we are bound to be in trouble. With a weak educational base, the technology will be weak.

In contrast to our mineral resources, agricultural resources have been taken seriously. Federal and matching state funds have continually supported education and research on agricultural resources at a university in each state since the first Hatch Act of 1887. As a consequence, we have continually trained experts we need in these fields at the many excellent colleges of agriculture in the country, and through research and extension programs have put into effect efficient production and conservation programs with respect to agricultural crops, forests, soils, wildlife, watershed management, etc. We in the U.S. can be very thankful for the wisdom

exhibited by Congress, first in creating the land grant colleges, and then 83 years ago providing funds to establish and continually maintain the state agricultural experiment stations.

In the case of our mineral resources we have had no such foresight. Support of mineral resources education and research has been sorely neglected. As one result, we find that one-third of the nation's university departments for education and research in mining engineering closed their doors during the five year period 1962-1967, despite an increasing demand for mining engineers. Comparable departments in colleges of agriculture such as entomology, plant pathology, horticulture, poultry science, agronomy, etc. continue throughout the United States to carry on strong programs aimed at solving the problems and keeping the United States at the forefront in agriculture science and technology. These agriculture programs have also sparked the so called "Green Revolution" which is so vital to developing nations. This is all possible because of a farsighted national policy providing among other things, continuing federal and state appropriations to the agricultural colleges.

The declining state of mineral engineering education in our universities is not primarily because of cost but is because of a lack of interest in support of these by federal and state governments.

Let us look briefly at some cost figures that I have obtained for disciplines at Penn State. This type of figure is calculated different ways at different institutions, but within a university, valid comparisons can be made among curricula. For the fall term of 1969, the cost per unit of instruction in mineral engineering was \$16.70; in agriculture, \$17.71, and in all other engineering, \$19.67. The unit cost was thus actually less for mineral engineering than for agricultural fields averaged, or for other engineering averaged.

And so if it is not cost, why are mineral engineering curricula being phased out?

One reason is that support of graduate and research programs in these fields has been very small. They have simply missed out on funding by federal agencies. Agriculture has the U.S. Department of Agriculture, but mineral engineering has the U.S. Bureau of Mines. The Bureau of Mines, has, as we know, steadfastly maintained through the years its policy of no support of education and research programs in universities. Many fields of engineering have received good support of their graduate and research programs from other federal agencies, especially DOD, AEC and NASA, but not mineral engineering.

The three extractive mineral engineering fields of mining, extractive metallurgy and petroleum engineering are notable for their relatively low level of funding of the graduate and research programs. This was emphasized in our recent National Academy report where the following statement appears (p, 77): "The total federal support of graduate and research programs reported for mining, extractive metallurgy, and petroleum engineering was only \$1.2 million a year in the fall of 1967. In these programs there was a total of 261 Ph.D. candidates and 467 M.S. candidates. The federal support of graduate students in these fields is thus less than \$2,000 per student per year. This compares with \$6,000 of federal support per graduate student per year in chemistry."² According to a recent NSF report,³ "On the average approximately \$1 million in Federal funds is associated with the award of seven doctorates in science and engineering," or approximately \$140,000 of Federal funds per doctorate. In mining and petroleum where there are now granted about 20 Ph.D. degrees per year in each field, the federal contribution per degree is only about \$15,000. Or in other words, per Ph.D. degree granted, mineral engineering receives only about one-tenth as much federal support as the average for Ph.D.'s in science and engineering in this country. On any basis, graduate programs in mineral science and engineering receive comparatively little federal support.

This lack of funding and absence of strong graduate and research programs as compared with other engineering, or with agriculture, or with most of science is one reason that mineral engineering departments have looked anemic and have disappeared.

Another reason is that university administrators tend to put great weight on the small number of students in some of the mineral engineering departments when compared with other engineering and science fields. This comparison I maintain is not a fair one. Mineral engineering, dealing with the nation's non-renewable resources, should be compared with agricultural fields which of course deal with

² Chemistry: Opportunities and Needs, NAS-NRC Publication 1292, National Academy of Sciences-National Research Council, Washington, D.C., 1965, p. 168.

³ "The Dynamics of Academic Science—A Degree Profile of Academic Science and Technology and the Contributions of Federal Funds for Academic Science to Universities and Colleges." National Science Foundation Report No. 67-6.

our renewable resources. Agriculture departments, such as agronomy or plant pathology, continue whether or not there is a large group of students. Note in the next slide the comparison of total 2nd, 3rd and 4th year enrollments in mineral engineering and in agriculture at Penn State University. The agriculture fields of entomology and plant pathology, incidentally, have no undergraduates at all—only graduate programs.

The curricula in agriculture are supported because of their importance to the nation. Strong faculty groups exist in these fields at the college of agriculture here at Ohio State and at Penn State and at a university in every state. With a college of agriculture in every state, despite low enrollments enough students are turned out, and we have the specialists being produced on an adequate scale. Broad spectrum research on the nation's agricultural problems is a continuing activity.

In my view there is no question as to the appropriate manner of financing or of the cost of mineral engineering education and research. We have learned how to finance the agricultural resources fields. Let us simply do what we know how to do well—support mineral engineering as we support agriculture. Annual appropriations for this purpose should be provided to the land grant college, or to some other designated institution in each state. We have made a start in this direction with the Water Resources Research Act of 1964.

Every state has important, essential mineral resources—sand, gravel, building stone, water, industrial minerals, etc., and in addition may have one or more of metallic ores, petroleum, natural gas or coal. Every state must sooner or later have problems of landfill locations for trash disposal and other problems where pollution of the underground is a serious threat. A strong mineral engineering program in a university in each state is an educational base of extreme need and importance. Crash programs are needed to take care of some of the worst situations, but for the long run it is essential that the education base be built up to provide the specialists and the fundamental knowledge to anticipate and handle the mineral resource and underground problems of this nation.

I have estimated that about \$25 million per year is what is needed in federal funds, and this will be matched by state funds, to build up and maintain viable mineral engineering groups at an educational institution in each state, as well as to support graduate and research programs on mineral problems in other institutions. This I am convinced is what is needed.

Those of us who appreciate the critical need for the knowledge and the specialists in mineral engineering, and who recognize the requirement for sound practices in mineral resource conservation and in utilization of the underground, must strive to reverse the deteriorating trend in mineral engineering education. I have pointed out that there is a way to do this. The cost in dollars is not high. The cost to the country will be increasingly great, however, as we continue to delay in adequately supporting education and research in the mineral resource fields.

Senator Moss. The Senator from Idaho, Mr. Jordan, do you have any opening remarks?

Senator JORDAN. No statement.

Senator ALLOTT. Mr. Chairman, I have several letters in support of this bill which I would like to insert at this point in the record.

Senator Moss. Without objection, they will be inserted at the conclusion of the testimony of Senator Allott. Mr. Jordan, you waived any opening?

(The documents referred to follow:)

ATLANTA, GA., April 23, 1971.

Senator GORDON ALLOTT,
Senate Office Building,
Washington, D.C.:

Highly in favor of your bill S-635. Have wired Senators Talmadge and Gambrell to urge support at hearing April 28.

LANE MITCHELL,
Director of Ceramic Engineering,
Georgia Institute of Technology.

STATE OF MISSOURI,
DIVISION OF GEOLOGICAL SURVEY AND WATER RESOURCES,
Rolla, Mo., April 12, 1971.

HON. GORDON ALLOTT,
*Senate Committee on Interior and Insular Affairs,
Senate Office Building, Washington, D.C.*

DEAR SIR: In my letter of March, 1971, I expressed the desirability of including state geological surveys as designated participants under Sec. 4(a)(4) of S. 635.

After a detailed study of S. 635 and discussions with other state geologists, I have become even stronger in my opinion concerning the active part that state surveys should play in mineral resource research under S. 635. In fact, it is entirely feasible that state geological surveys should be designated as the principal mining, minerals, and related environmental research institutes in those states that support active state geological surveys.

State geological surveys—or their equivalent state agencies—in 49 states and Puerto Rico are the state agencies that have been active in, and concerned with, the nation's mineral resources. This is evidenced by the strong support of the Association of American State Geologists in favor of passage of the Mining and Minerals Policy Act of 1970.

A considerable number of state surveys have subsidized university staff and students engaged in mineral resource investigation. It has seldom been that the universities have assisted the state surveys in such projects. The state surveys are the prime source of data for university requests regarding mineral resource data that are usually supplied (and even tabulated or compiled) at minimal expense to the recipient.

Although Colorado, Missouri, and Nevada are most fortunate in having perhaps the outstanding "schools of mines," there are only some seventeen educational institutions in the United States with accredited mining engineering curriculum.

Many state surveys have a long record of active participation in cooperative programs relating to mineral resources with the U.S. Geological Survey and the U.S. Bureau of Mines. In 1964, during the formative stages of the Water Resource Research Act, the Association of American State Geologists urged ". . . the expansion and acceleration of the program for collection of basic water data by the U.S. Geological Survey; that provision be made for adequate analysis and synthesis of these data; and that adequate liaison with, and utilization of, existing water resources agencies in the several states be developed."

I hope that serious consideration be given the thoughts expressed above in your deliberations of S. 635.

Respectfully,

WILLIAM C. HAYES,
State Geologist and Director.

THE COLORADO MINING ASSOCIATION,
Denver, Colo., April 20, 1971.

HON. GORDON ALLOTT,
*New Senate Office Building,
Washington, D.C.*

DEAR GORDON: This is to advise you that the Colorado Mining Association endorses S. 635, *To amend the mining and minerals policy act of 1970*, as introduced by you on February 5, 1971.

This bill recognizes the necessity of strengthening the professional arm of the mining industry by revitalizing education in mining and allied fields. In 1967, only 17 educational institutions had an accredited curriculum in mining engineering. The median number of students was approximately 6. There were at the same time, 19 graduate students, and 48 per cent of these were foreign nationals.

This bill should provide some inducement for educational institutions to provide better facilities and education in this field. While it is a step in the right direction, the monies appropriated will not provide too much more than we have at present. The monies to be appropriated could only provide adequate facilities, equipment, and staff at one location. If the money is to be divided equally among 50 states, the individual amounts received would hardly be effective. I would certainly encourage states to join with one another so that meaningful institutions with competent staffing would be realized.

The ultimate effectiveness of this proposal will depend upon its administration by the Secretary of the Interior and the colleges involved. If administered properly, there are many useful projects that can be accomplished.

Sincerely yours,

DAVID R. COLE, *Manager.*

MICHIGAN TECHNOLOGICAL UNIVERSITY,
COLLEGE OF SCIENCES AND ARTS,
Houghton, Mich., June 10, 1971.

Senator GORDON ALLOTT,
Washington, D.C.

DEAR SENATOR ALLOTT: I am wholeheartedly in favor of the philosophy and need expressed in the bill, S. 635, which you have introduced into the legislature. The bill provides Federal assistance for research and training in the mineral industries at a number of our nation's colleges and universities. This assistance is imperative to insure the well being of the industry and the country.

The mineral industry of the United States faces a long term production crisis in order to supply a sufficient quantity of fuels and raw materials at a reasonable cost. The news laws regarding environment, health, and safety will increase the cost and technical problems of meeting the demand. In addition, the increased technical problems and attendant costs created a demand for mineral technologists and engineers that present colleges and universities cannot provide.

It is therefore imperative that Mineral Sciences and Technology begin expansion *now*. The minimum time lag in engineering is four years at the B.S. level and six to seven years at the M.S. and Ph. D. level. Most of the research within the university training system is accomplished after the B.S. level. Thus, even though the legislation were to be enacted this year, peak results cannot be obtained for a number of years and most likely will not occur until near the end of this decade.

There is no way to provide instant education and training. The time to begin is *now*. Your bill will provide the means of accomplishing this objective.

Sincerely,

LLOYD O. BACON,
Professor of Geophysics.

MACKAY SCHOOL OF MINES,
UNIVERSITY OF NEVADA,
Reno, Nev., April 23, 1971.

HON. GORDON L. ALLOTT,
*Senate Subcommittee on Minerals, Materials, and Fuels, Senate Office Building,
Washington, D.C.*

DEAR SENATOR ALLOTT: A moments reflection is sufficient to convince a person that there are but two basic and fundamental industries and that all other human economic activity depends upon the satisfactory operation of: (1) the industry involved with living resources; that is agriculture (including forestry, fishing, etc.) and (2) the industry involved with non-living resources; that is the mineral industry. Without either of these industries; which compose the first level of human economic activity; the world, as we know it, ceases to exist and man becomes a wandering animal. Thus it is folly to debate which is more important: agriculture or mineral industry. Other levels of human economic activity are important to the life of our nation but they cannot exist without the first level.

Some hundred years ago Congress recognized that a healthy agricultural industry was necessary to our nation's well-being and by means of the Morrill and other Acts created agricultural research and training institutes throughout America. The results are world famous. Regrettably, research and training institutes for the non-living (earth and mineral) resources were not established at that time. Thus, America, although well-supplied by nature with mineral materials, has paid a heavy price through lack of research and training. The nation that does not consider the economic condition of each of its two basic industries may soon lose its right of free choice in guiding its own future in the world.

The time has come for America to think about its earth and mineral (non-living) resources. The education and research necessary for these resources to be properly extracted and used must be supported and encouraged. Then, and only then, will America know that both of its basic and fundamental industries will be healthy and will contribute to our Nation's safety and well-being.

As Dean of one of America's few remaining mineral industry colleges and as Director of one of our most active state bureau's of mines, I sincerely urge you to support the passage of S. 635; which calls for the establishment of mineral resources research and training institutes throughout America.

Most respectfully yours,

VERNON E. SCHEID,
Dean and Director.

AMERICAN INSTITUTE OF MINING,
METALLURGICAL AND PETROLEUM ENGINEERS,
UPPER PENINSULA SECTION,
July 12, 1971.

Reply to: Institute of Mineral Research, Michigan Technological University,
Houghton, Mich.

Hon. GORDON ALLOTT,
U.S. Senate,
Washington, D.C.

DEAR SENATOR ALLOTT; The Upper Peninsula Section of the American Institute of Mining, Metallurgical and Petroleum Engineers has authorized me, as Chairman of the Section, to express to you the support of the Section and its members for the legislation S. 635, which you have introduced in the 92d Congress to provide essential financial support for education and research for the nation's mineral industry. The Upper Peninsula Section geographically includes the Upper Peninsula of Michigan plus several of the northern counties of Wisconsin. The Section has a membership of approximately 350 engineers and scientists professionally engaged in the mineral industry. The area encompassed has had an active history as a mining district, producing iron ore, copper, limestone, and a variety of other mineral products for over 100 years.

The Section recognizes that maintenance of a flourishing domestic mineral industry is vital to the continued well-being of the nation's economy and security. We also clearly recognize that this industry faces serious problems related to the demands for increased production, the preservation of our environment, and the health and safety of its employees. We are seriously concerned that these problems be solved in a manner acceptable to society and the industry.

We further recognize that solution of the problems facing the mineral industry will require the dedicated efforts of many kinds of scientists and engineers. The university campus affords a unique opportunity for this type of interdisciplinary study and research.

For all these reasons, the members of the U.P. Section are deeply disturbed by the present trend toward elimination of university programs of education and research concerned with the mineral industry. We consider the financial support proposed in Senate Bill S. 635 as absolutely essential if this trend is to be reversed. If the trend is not reversed, if skilled professional people no longer enter the industry in sufficient number, if the necessary research is not done, the industry and our nation can only suffer consequences of immense magnitude. On the other hand, we are convinced that, given adequate Federal support for education and research, the problems facing the industry will be solved.

The Upper Peninsula Section of AIME is grateful for this opportunity to express our concerns and hopes regarding our country's mineral industry, and we deeply appreciate your efforts on behalf of that industry.

Very truly yours,

W. L. FREYBERGER, *Chairman.*

NEW MEXICO INSTITUTE OF MINING AND TECHNOLOGY,
OFFICE OF THE PRESIDENT,
Socorro, N. Mex., April 26, 1971.

Hon. GORDON ALLOTT,
U.S. Senate,
Committee on Interior and Insular Affairs,
Washington, D.C.

DEAR SENATOR ALLOTT: I would like to submit the following statement in support of S. 635:

The extraction and beneficiation of minerals needs the creative reinforcement that has been so overwhelmingly successful in the rest of science and engineering, namely, the financial educational stimulation of the National Science Foundation. This independent reinforcement of creative ideas, as opposed to the purely financial reward in the market place, is needed in the United States and the world with greater urgency than before because:

1. The mining of lower-grade deposits necessitates at present a greater ecological transgression;
2. Population growth has not yet allowed a recycling economy.

Mineral education hithertofore has been isolated from the other educational financial sources because of the existence of the U.S. Bureau of Mines with, at the same time, no consistent educational support policy.

I strongly support aid to mineral education. I firmly believe that this support should be approximately equally divided between:

1. Institute grant-in-aid or department type funding and
2. Independent research proposal support administered as does the National Science Foundation with anonymous independent peer group review.

Sincerely yours,

STIRLING A. COLGATE,
President and Director of Research.

Senator ALLOTT. Mr. Chairman, I have been informed that my presence is required at the hearing on Senate resolution 45, before the Committee on Rules and Administration. As you know, that resolution authorize this committee to conduct an energy study. However, I wish to advise both the members of the committee and the witnesses to be heard, that I shall return as soon as that business is consummated.

Senator Moss. Senator Bellmon?

STATEMENT OF HON. HENRY BELLMON, U.S. SENATOR FROM THE STATE OF OKLAHOMA

Senator BELLMON. I would like to compliment the chairman for holding the hearings and also Senator Allott for the leadership he is showing in presenting this bill to the Senate. I would also like to ask consent to be listed as a cosponsor of this legislation.

Senator Moss. As far as the record here is concerned that will be accomplished. I suggest it also be noted on the floor.

Senator BELLMON. Oklahoma is one of the States that is vitally interested in the mining and minerals industries. In our State petroleum is the largest single nonagricultural industry and represents a substantial portion of our economy.

Lead and zinc mining have for many years been major industries in the northeastern Ozark region of Oklahoma, and large-scale mining of vast coal deposits in eastern Oklahoma is just beginning. On the opposite side of the State, the extration of copper is developing into a major enterprise. Gypsum, limestone, and many other minerals are mined in large and growing quantities.

The health and vitality of Oklahoma's economy always has been, and will continue to be, directly related to the extractive industries. The establishment of a research institute within the State to deal directly with the problems associated with the industry would be highly advantageous to the entire State.

On a much broader scale, the establishment of a series of mineral research centers throughout the country is a matter of important priority at this time. Our nonrenewable supplies of essential minerals are being exhausted at a faster rate than any other natural resource, and the time has come to face up to the probability of critical shortages in the not-too-distant future.

Expanded and innovative research is absolutely essential if we are to meet needs, even in our lifetime, for minerals of all kinds. At the present rate of consumption, known reserves of natural gas will last only about 15 years. Silver, tin, uranium, and crude oil reserves will probably be exhausted in 30 years, and the supplies of platinum, gold, zinc, and lead will likely last not more than 50 years.

Coal deposits still exist in large quantities, sufficient for perhaps 1,000 years. But serious air pollution problems are associated with its use on a large scale, and extraction processes create other major

environmental problems. Additional technological improvements are needed if we are to realize the potential of our coal reserves.

While there is disagreement on the prospects of locating substantial new reserves of minerals, reliance on such discoveries would seem to be an unwise course for future planning. A major expansion of research in all aspects of mineral technology, production, use, conservation, and recycling is necessary today if we are to be assured of adequate supplies of essential minerals for modern industrial society.

Contrary to the need, the amount of mineral research being done in this country is declining and the number of mineral technologists produced in our colleges and universities is declining. This decline in research and education will simply hasten the day when we are confronted by a major minerals crisis—a crisis that can be avoided if we act now.

The concept of mineral research centers in each State, as provided in Senate bill 635, is a sound and logical approach to meeting the challenge facing the mining and minerals industry. Enactment of this legislation will help encourage the training of more scientists and technicians in the mineral field, it will encourage research at the State and regional levels to solve mineral-related problems of both regional and national concern, and will help assure the Nation adequate supplies of all minerals and their products both for the present and the future.

Mr. Chairman, I am very pleased to join in support of this legislation.

Senator Moss. Thank you, we appreciate your statement and your participation in the hearings. I regret Senator Allott is going to have to be in and out because of other commitments.

We have Senator Stevens of Alaska.

Senator STEVENS. I am very pleased to be a cosponsor of the bill, Mr. Chairman, and to see that Dr. Earl Beistline of the University of Alaska is here. I also have to leave to go out and debate a little matter called the Alaska pipeline in Los Angeles this evening and I may not stay very long. I appreciate your courtesy.

Senator Moss. We are glad you are here and hope you can remain for at least some of the presentation because we do indeed have a long and distinguished list of witnesses. We are pleased that so many of you were able to respond and come to this hearing.

To begin with, I will order that wherever you have a prepared text the entire text will go in the record and will be there when the record is printed up. This will enable the witnesses, if they care to do so, to direct their attention to particular parts of their statements which they think should be emphasized or highlighted and if they have a difference with the preceding witness, they may want to point out that difference.

It would not then be necessary to read every single word of the prepared statement. We have an outstanding list of witnesses and I do not want to preclude anyone from delivering his testimony in the way he thinks is best.

We will proceed with the different panel groups. The first panel will be Dr. James Boyd, chairman of the board, Copper Range Co., New York; Dr. Oscar Marzke, vice president of United States Steel, Pittsburgh; and Dr. Martin Elliott, Texas Eastern Transmission, Houston, Tex.

Will those three gentlemen sit at the table here, please? I see we only have two microphones so we are going to have to share on that. We do have many interested people in the audience and we want you to be heard so we hope whoever is speaking will use the microphone at that time.

Dr. Boyd, will you lead off?

**STATEMENT OF DR. JAMES BOYD, CHAIRMAN OF THE BOARD,
COPPER RANGE CO.**

Dr. BOYD. Thank you, Mr. Chairman. I am James Boyd, chairman of the board of Copper Range Co., and appear today in support of S. 635, representing the American Mining Congress, an association of U.S. companies that produce most of the Nation's metals, coal, and industrial and agricultural minerals. Its membership includes also more than 200 manufacturers of mining and mineral processing equipment and supplies as well as financial institutions with a business interest in the mining industry.

In 1969 I was president of the American Institute of Mining, Metallurgical, & Petroleum Engineers. Although that institute is not permitted to come to political conclusions, I may say that I have been in touch with the pertinent committees of the institute enough to be able to say to you that the profession supports the principles of S. 635 even if individual members might prefer to have different approaches to some of its provisions. As you know, it is always difficult to get a group of engineers to come to unanimous conclusions.

For myself, I am the son of a mining engineer and was brought up in the gold camps of western Australia. I graduated from the California Institute of Technology in engineering and economics, and received advanced degrees in geology and geophysics from the Colorado School of Mines. I served in the Government, involved in raw material supply problems, during World War II, as a member of the Army and Navy Munitions Board staff, and later, as the Director of the U.S. Bureau of Mines, and Administrator of the Defense Minerals Administration during the Korean war.

I was, for a period, vice president of Kennecott Copper Corp. in charge of exploration, and have been with Copper Range Co. for 11 years. I am a member of the National Academy of Engineering, and served on the committee of the academy which wrote the mineral science and technology report for the Interior Department. I also served for 3 years as the Chairman of the National Science Foundation's Committee on Mineral Research, and currently am chairman of the Interior Secretary's Advisory Committee—Metal and Non-metallic Mine Safety Act.

It is always a matter of pride to me to have the privilege of appearing before this committee, which I have done many times since my first appearance 24 years ago. Today, although I represent the American Mining Congress in support of S. 635, I propose to support its position by more personal experience.

Through all of the years that I have been related to the minerals profession, the Congress and various administrations have struggled with the enormous task of assuring the economy sufficient raw materials to keep it growing, while conserving our resources and preserving the environment. The problems are changing so rapidly that adjustments of policy are constantly required.

In supporting S. 635, the mining industry is assuming an unusual position, for it has tried, wherever possible, to solve its basic problems within its ranks. But times have indeed changed, and we find that we cannot solve all the problems facing us without help from the State. One reason is that the State imposes certain restrictions on us which inhibit our ability to cope with many conditions on a concerted basis.

There are many reasons why this legislation is needed. The demand for trained manpower ebbs and flows between the time a young person decides what he wants to do with his life and when he is prepared to assume his responsibilities. We sometimes find that the demand has temporarily slackened when these same young people become available. Today some graduate engineers cannot readily find a job.

The most dramatic illustration can be found in space technology. Here the sudden change in national priorities has thrown thousands of engineers and technologists with specific, sometimes narrow training and experience, out of work. Yet the need for trained men in the environmental sciences exceeds the supply by a substantial margin.

The requirements for the most creative types of minds in the earth science and technology fields are perhaps most pressing, as too many of those having such potential were drawn into those fields where priorities are now declining. The disciplines addressed by S. 635 need the infusion of many more minds competent by intellect and training to meet their growing challenges. To provide these men with adequate training, under our educational system, requires exposure to new thoughts, modes of attack on problems, and new knowledge coming from research.

Such research takes place in industry, the research institutions, the government bureaus, and the universities. To a large extent we have to depend on the latter for the generation of fundamental knowledge. We found in our studies when writing the mineral science and technology report of the Academies of Science and Engineering that the universities were woefully short of funds to provide the opportunities for scientific discovery in the mineral fields. In fact, it appears that the rest of the world is leaving us far behind.

Now, let me illustrate what I mean from experience within my own company. We operate a very large underground mine, producing the fifth largest amount of copper in this country. This mine is so unique that we have had to develop new technologies to mine it successfully. For over 25 years we have necessarily been spending an unusually large portion of our income to develop new mining technologies. In fact, millions of private dollars were spent on research before the decision to mine could be made at all.

This is a very large bite for a small company, but the knowledge gained from this work is being used all over the world. I took a trip around the world last year, Mr. Chairman, and saw things developed in Michigan being used in the mines of Australia.

We, as a relatively small company, simply cannot afford to do much of the fundamental work that is required to solve problems which we may have in common with those of other companies.

For example, we find that the future of our mine depends somewhat on the effective development of boring machines. We have pioneered in using these machines for tunneling purposes in hard rock, but with many unsolved difficulties. This is a brand new technology, which will make major contributions outside the mining industry. For example,

the solution to some transportation problems, in urban areas will depend on rapid excavation of tunnels, using such machines.

Unfortunately, we do not really know why or how this machine works. We cannot see the cutters operating or, with our facilities, have them instrumented to determine the forces involved. We need to do the kind of things that the aircraft designers do in a wind tunnel, where they can see what goes on, instrument models to provide the physical data, and create constant but variable conditions so that they can test out their theories.

The advances in space and aeronautical technology have come out of tremendous expenditures on research in hundreds of institutions. By comparison, the work done on the sciences of the earth is so small as to be negligible and is attempted in only a limited way in very few colleges and universities. Just as the technology developed by extensive research in space has provided answers to many pressing problems, so extensive research in the earth sciences is required to answer many national problems involving all phases of the environment in which we live.

We in Copper Range have started with a survey of the state of the art in each of the fields we encounter. From there on, however, we have had to achieve results by developing information empirically. We can try out new things as we produce rock for our mills. Our work would be more effective and less expensive if we could look toward the educational and research institutions for fundamental physical constants and operating data.

We have had to man our machines with engineers who in some instances have gone back to college for advanced degrees. They, however, do not have available to them the reservoirs of knowledge of fundamental and applied research that exist in other fields. The Government has seen this need in the physical science, in agriculture, space and medical technology, but not in the mineral sciences.

As I talk with our engineers and research men, I constantly hear about struggles to solve an urgent problem only to run up against a serious lack of developed technology. Some very pressing questions will not be answered until research produces new technology.

Up to now we have been blessed with abundant supplies of readily discovered and accessible mineral raw materials. The solution to technical problems could usually be handled by ingenious engineers who could improvise and accomplish the desired result. Others have pointed out or will point out that this is no longer so. The resources exist within our territories, but the technology to recover them in sufficient quantities at reasonable costs does not. To accomplish this we are required to speed up our research and to produce more competent graduates to deal with the enormously complicated problems involved.

In the meantime, even more complicated technologies are required to provide the means by which minerals can be made available for general use, without damaging the environment or so disturbing the ecology as to make it difficult to adjust to mineral industrial activities.

I have here a list of a great many such items which I won't read to you here.

Senator Moss. Thank you. It will be in the record in full.

Dr. BOYD. Such measurements are desperately needed in order to provide the scientist with data which he can use to investigate new

mine schemes more compatible with our ecology. The engineer-designer can use such data to develop more efficient mining and processing equipment to fit the schemes proposed by the scientist.

Breakthroughs in mining must be made in order to maintain or increase the present standard of living within acceptable ecological parameters.

If the ecology is to be maintained and material necessities are to be provided for our ever-expanding population, new mining methods must be developed.

These new developments could mutually assist in providing a solution to the present urban problems dealing with transportation and waste disposal.

In the preparation of this statement many questions have been raised about the completeness or the workability of this bill. I personally feel that those who drafted it did a magnificent job of covering almost all of these questions. For emphasis, however, I should like to present you with some of these concerns so that when you mark up the bill you will possibly have useful comments.

The requirements for this type of assistance are so broad that it is possible to feel that one technology has been emphasized at the expense of another. I mean, we may have said more about mining than we ever did about fuel, things of that nature.

The policy statement in section 3 is indeed all-inclusive. Considerable work needs to be done in all these. It is to be hoped that the legislative history of this act will indicate that one part is as important as another, even though from time to time the priorities can change.

Some of my correspondents are concerned that the bill is too broad, and that applying it to all States could weaken its coverage. It is recognized, however, that every State, even the smallest, has mineral or earth science problems and that in virtually every one the problems can be unique. It is recognized that education is organized on a State basis, and as nobody has suggested to me a better way, I would not like to recommend an amendment.

The metal mining industry, and indeed the academies in their reports, feel the need to concentrate efforts in fewer centers which can be brought to high levels of excellence. Section 4a(3), which provides for interstate cooperation, seems to me to provide the means of accomplishing this end. This type of cooperation is not easy to achieve. I would hope that the Secretary of the Interior would be charged to encourage this type of cooperation. Perhaps the committee would agree with us and have its record indicate its purpose.

Mr. Chairman, I appreciate the opportunity of appearing before you and I would like to express my admiration for a well-drafted bill. I would hope that those who feel they have a better way to do things will try to find that way within the structure you have provided.

Senator Moss. Well, thank you for your fine statement and we will indeed consider all suggestions that are made for any amendment or improvement of the bill possible and what we want is the widest possible record on which to form our judgments.

We are glad to have your statement of approval in representing the American Mining Congress. We are very glad to know there is a general support there from the members of the Congress. Are there any questions of Mr. Boyd?

All right, thank you, we will go on then to Mr. Marzke of U.S. Steel.

(Mr. Boyd's prepared statement follows:)

STATEMENT OF DR. JAMES BOYD, CHAIRMAN OF THE BOARD, COPPER RANGE CO.

Mr. Chairman and Members of the Subcommittee, my name is James Boyd. I am Chairman of the Board of the Copper Range Company and appear today in support of S. 635, representing the American Mining Congress, an association of U.S. companies that produce most of the nation's metals, coal and industrial and agricultural minerals. Its membership includes also more than 200 manufacturers of mining and mineral processing equipment and supplies as well as financial institutions with a business interest in the mining industry.

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Through all of the years that I have been related to the minerals profession, the Congress and various administrations have struggled with the enormous task of assuring the economy sufficient raw materials to keep it growing, while conserving our resources and preserving the environment. The problems are changing so rapidly that adjustments of policy are constantly required.

In supporting S. 635, the mining industry is assuming an unusual position, for it has tried, wherever possible, to solve its basic problems within its ranks. But times have indeed changed, and we find that we cannot solve all the problems facing us without help from the state. One reason is that the state imposes certain restrictions on us which inhibit our ability to cope with many conditions on a concerted basis.

There are many reasons why this legislation is needed. The demand for trained manpower ebbs and flows between the time a young person decides what he wants to do with his life and when he is prepared to assume his responsibilities. We sometimes find that the demand has temporarily slackened when these same young people become available. Today some graduate engineers cannot readily find a job.

The most dramatic illustration can be found in space technology. Here the sudden change in national priorities has thrown thousands of engineers and technologists with specific, sometimes narrow training and experience, out of work. Yet the need for trained men in the environmental sciences exceeds the supply by a substantial margin. The requirements for the most creative types of minds in the earth science and technology fields are perhaps most pressing, as too many of those having such potential were drawn into those fields where priorities are now declining. The disciplines addressed by S. 635 need the infusion of many more minds competent by intellect and training to meet their growing challenges. To provide these men with adequate training, under our educational system, requires exposure to new thoughts, modes of attack on problems, and new knowledge coming from research.

Such research takes place in industry, the research institutions, the government bureaus, and the universities. To a large extent we have to depend on the latter for the generation of fundamental knowledge. We found in our studies when writing the Mineral Science and Technology report of the Academies of Science and Engineering, that the universities were woefully short of funds to provide the opportunities for scientific discovery in the mineral fields. In fact, it appears that the rest of the world is leaving us far behind.

Now, let me illustrate what I mean from experience within my own company. We operate a very large underground mine, producing the fifth largest amount of copper in this country. This mine is so unique that we have had to develop new technologies to mine it successfully. For over 25 years we have necessarily been spending an unusually large portion of our income to develop new mining technologies. In fact, millions of private dollars were spent on research before the decision to mine could be made at all. This is a very large bite for a small company, but the knowledge gained from this work is being used all over the world. Even this large contribution, however, is not enough. We, as a relatively small company, simply cannot afford to do much of the fundamental work that is required to solve problems which we may have in common with those of other companies.

For example, we find that the future of our mine depends somewhat on the effective development of boring machines. We have pioneered in using these machines for tunneling purposes in hard rock, but with many unsolved difficulties. This is a brand new technology, which will make major contributions outside the mining industry. For example, the solution to some transportation problems in urban areas will depend on rapid excavation of tunnels, using such machines.

Unfortunately, we do not really know why or how this machine works. We cannot see the cutters operating or, with our facilities, have them instrumented to determine the forces involved. We need to do the kind of things that the aircraft designers do in a wind tunnel, where they can see what goes on, instrument models to provide the physical data, and create constant but variable conditions so that they can test out their theories. The advances in space and aeronautical technology have come out of tremendous expenditures on research in hundreds of institutions. By comparison, the work done on the sciences of the earth is so small as to be negligible and is attempted in only a limited way in very few colleges and universities. Just as the technology developed by extensive research in space has provided answers to many pressing problems, so extensive research in the earth sciences is required to answer many national problems involving all phases of the environment in which we live.

We in Copper Range have started with a survey of the state of the art in each of the fields we encounter. From there on, however, we have to achieve results by developing information empirically. We can try out new things as we produce rock for our mills. Our work would be more effective and less expensive if we could look toward the educational and research institutions for fundamental physical constants and operating data.

We have had to man our machines with engineers who in some instances have gone back to college for advanced degrees. They, however, do not have available to them the reservoirs of knowledge of fundamental and applied research that exist in other fields. The government has seen this need in the physical sciences, in agriculture, space and medical technology, but not in the mineral sciences.

As I talk with our engineers and research men, I constantly hear about struggles to solve an urgent problem only to run up against a serious lack of developed technology. Some very pressing questions will not be answered until research produces new technology.

Up to now we have been blessed with abundant supplies of readily discovered and accessible mineral raw materials. The solution to technical problems could usually be handled by ingenious engineers who could improvise and accomplish the desired result. Others have pointed or will point out that this is no longer so. The resources exist within our territories, but the technology to recover them in sufficient quantities at reasonable costs does not. To accomplish this we are required to speed up our research and to produce more competent graduates to deal with the enormously complicated problems involved.

In the meantime, even more complicated technologies are required to provide the means by which minerals can be made available for general use, without damaging the environment or so disturbing the ecology as to make it difficult to adjust to mineral industrial activities. A few such areas are:

1. The more efficient use of chemical energy (explosives).

2. Application of sonic and impact energy as applied to the mechanical cutting of rock.
3. Optimum cutter, shape and head design for boring machines.
4. Changing the rock shape fabric through application of chemicals to promote softening, possibly coupled with additional research in rock cutting with water jets.
5. Metallurgical research to test the feasibility of mineral preconcentration on removal within the mine environment without use of present massive rock displacement.
6. As to rock breaking, generally, investigation of new energy sources such as radiant heat, electron beams, plasma arc, lasers and electromagnetics. However, advancement and application of new techniques must depend upon generalization of rock data.
7. Development of suitable equipment and techniques for measurement of in situ physical characteristics of rocks. Little has been done in this area although the science of precise measurement has been advanced to a high degree in the aerospace industry.

Almost every competent mining company could provide you with longer and possibly more urgent lists.

Such measurements are desperately needed in order to provide the scientist with data which he can use to investigate new mine schemes more compatible with our ecology. The engineer-designer can use such data to develop more efficient mining and processing equipment to fit the schemes proposed by the scientist.

Breakthroughs in mining must be made in order to maintain or increase the present standard of living within acceptable ecological parameters.

If the ecology is to be maintained and material necessities are to be provided for our ever-expanding population, new mining methods must be developed.

These new developments could mutually assist in providing a solution to the present urban problems dealing with transportation and waste disposal.

In the preparation of this statement many questions have been raised about the completeness or the workability of this bill. I personally feel that those who drafted it did a magnificent job of covering almost all of these questions. For emphasis, however, I should like to present you with some of these concerns so that when you mark up the bill you will possibly have useful comments.

The requirements for this type of assistance are so broad that it is possible to feel that one technology has been emphasized at the expense of another. The policy statement in Section 3 is indeed all inclusive. Considerable work needs to be done in all these. It is to be hoped that the legislative history of this act will indicate that one part is as important as another, even though from time to time the priorities can change.

Some of my correspondents are concerned that the bill is too broad, and that applying it to all states could weaken its coverage. It is recognized, however, that every state, even the smallest, has mineral or earth-science problems and that in virtually every one the problems can be unique. It is recognized that education is organized on a state basis, and as nobody has suggested to me a better way, I would not like to recommend an amendment.

The metal mining industry, and indeed the academies in their reports, feel the need to concentrate efforts in fewer centers which can be brought to high levels of excellence. Section 4a(3), which provides for interstate cooperation, seems to me to provide the means of accomplishing this end. This type of cooperation is not easy to achieve. I would hope that the Secretary of the Interior would be charged to encourage this type of cooperation. Perhaps the committee would agree with us and have its record indicate its purpose.

Mr. Chairman, I appreciate the opportunity of appearing before you and I would like to express my admiration for a well-drafted bill. I would hope that those who feel they have a better way to do things will try to find that way within the structure you have provided.

STATEMENT OF DR. OSCAR MARZKE, VICE PRESIDENT, UNITED STATES STEEL, PITTSBURGH, PA.

Dr. MARZKE. Thank you, Mr. Chairman. My name is Oscar Marzke. I am vice president for fundamental research of the United States Steel Co. I am here today as a representative of the Committee

on General Research of the American Iron & Steel Institute, a committee composed of top-level research administrators for some 25 major steel companies. The committee supports this bill. Another major committee of the institute, that on manufacturing problems, which is a committee made up of principal operating or production officers of the member companies, also supports the bill.

For more than a dozen years, many of us in the steel industry concerned with its technology have been painfully aware of the shortage of an adequate number of properly trained personnel in mining and process metallurgy. Under the term "process metallurgy," I am including beneficiation of ores, smelting, refining, and casting.

As a result of the demand for materials of improved characteristics for military, space and atomic energy applications, the Federal Government made large sums of money available to academic institutions for research and development of new materials and for training manpower necessary for this type of work.

Interest in a field usually goes where the money is. Consequently, there was a pronounced buildup of research and teaching capabilities in what is now often referred to as the field of materials science. This, however, was in general accompanied by a deterioration in mining and process metallurgy activities.

A vicious cycle developed in these latter areas. The lack of money resulted in reduced research by the professors. This was evident to the students with the result that there has been a steady decrease in interest on the part of the students.

The situation has been brought to the attention of representatives of the majority of the Federal science and technology funding agencies on several occasions during the past several years. The usual reaction of these representatives was that this problem is one for the metals industry to handle; it is not one of national concern.

While the metals industry does, of course, recognize its obligation, the funds which it has available for support of research in academic institutions cannot approach those of the Federal Government. The industry has for many years supported on a significant scale the acquisition of basic or fundamental information relative to reduction and refining operations. In fact, if it had not been for such support on the part of the American Iron & Steel Institute, I believe the situation would be even more serious than it is now.

I do not propose to elaborate upon what has happened in the academic institutions. This has been discussed in considerable detail in the National Academy of Sciences report entitled "Mineral Science and Technology: Needs, Challenges, and Opportunities." It will undoubtedly be further discussed by the academic people who are also scheduled to testify in behalf of this bill.

You may well ask what has industry been doing to meet its requirements for personnel in these fields. It has taken people having related training and experience and retrained them at considerable expense of both time and money.

It has also brought in people from abroad. It may be of interest to you that at a recent conference concerned with steelmaking 18 percent of the technical papers were given by foreigners. An additional 10 percent were authored by foreign-trained personnel working for U.S. companies. In my own research group working in this area, about 25 percent of the key people received their training abroad.

Our, that is United States Steel's Operating Department informed me that in 1967-68 they were able to hire only about 60 percent of the metallurgists and 15 percent of the mining engineers they needed. In 1969-70, the situation improved somewhat; they were able to hire 70 percent of the metallurgists and 45 percent of the mining engineers.

The improvement in the hiring of metallurgists was in some measure due to the increase in demand for such people by other industries. Today, because of the general economic climate, we are able to meet a significantly higher percentage of our needs, but I must add that and because of the economic climate our needs have decreased also.

The present situation, we believe, is only temporary; hopefully the economy will improve in the very near future. Furthermore, our industry is faced with several major new problems, problems that will require additional knowledge and people with extensive training in process or extractive metallurgy.

These problems are the result of (1) restrictions imposed by ecological demands and legislation; (2) the need to utilize lower grade raw materials and the growing emphasis on recycling of waste materials; (3) demands for improved working conditions; (4) the effects of inflation on costs of facilities; and (5) the increase in cost of production due to higher wage rates.

The accumulative effect of these factors demand major improvements in the control of existing processes and will force the introduction of new, perhaps radically new, technology. Unrestricted imports will increase the pressures for economic solutions to these problems. While some of these may not normally be considered appropriate problems for academic research, all of them require more knowledge and understanding which are the products of basic or fundamental research.

Traditionally such research is carried out in academic institutions. The application of these basic findings to the solution of the real problems which is industry's responsibility will require more creative, highly trained people. Again, the universities are the source of these. This bill should help to meet the knowledge and manpower requirements. It would greatly assist our industry to meet its responsibilities.

Senator MOSS. Thank you very much, sir, for that statement, representing the American Iron & Steel Institute. In emphasizing the problems which you did on page 3 of your writtent text, you talked about the growing emphasis on recycling of waste material. Is that a very considerable problem now in the iron and steel business?

Dr. MARZKE. A great deal of attention has been put on it in recent months, in fact for the last couple of years. The handling of tin cans, for example, wrecked automobiles or old automobiles. Yes. This is a major problem.

Senator MOSS. Yet, there isn't a great deal of economic incentive for doing that, is there?

Dr. MARZKE. There is none, really. It is rather costly.

Senator MOSS. As I thought about that, this is a particular area where research in an academic institution could concentrate on the problem so that it could become economical to the industry but it has the side effect of the protection of the environment which is all around us now.

Dr. MARZKE. I have the feeling, sir, this is not so much a problem of basic research as straight economics.

Senator MOSS. Well, perhaps the research might not—

Dr. MARZKE. There could be an input, surely, from the research.

Senator MOSS. There might be a way of improving this so that the economics could improve. Thank you very much.

Senator BELLMON. As your statement implies, there is a surplus of these people abroad. You indicate you have 25 percent of your key people receiving their training abroad and 10 percent offered by foreign-trained personnel working for U.S. companies. Is there some reason for the existence of a surplus of trained people abroad?

Dr. MARZKE. I didn't mean to imply there was a surplus abroad. They are more readily available abroad. Our higher wage rates and better working conditions enable us to seduce the people from abroad. I think that is the real situation. They do turn out more people in these areas abroad than we do.

Senator BELLMON. In the earth sciences?

Dr. MARZKE. In process metallurgists. I shouldn't make such a sweeping statement, but there are schools that turn out more than the majority of our schools.

Senator MOSS. I think the testimony last year indicated the great decline that has been going on in our universities of turning out metallurgical engineers of various kinds. It has been going down at an alarming rate.

Dr. Martin Elliott, Texas Eastern Transmission, will be our third witness and we are glad to hear from you, Dr. Elliott.

STATEMENT OF DR. MARTIN A. ELLIOTT, CORPORATE SCIENTIFIC ADVISER, TEXAS EASTERN TRANSMISSION CORP., HOUSTON, TEX.

Dr. ELLIOTT. Mr. Chairman, members of the subcommittee, I am Martin Elliott. I greatly appreciate the opportunity to appear before you today and to register support for the pending bill, S. 635.

The bill as a whole is of great importance to the broad field of mineral science and technology. Inasmuch as my entire professional career has been in the field of fuel science and technology, my comments will be addressed to that part of the broader field.

My association with the field of fuel science and technology began with my undergraduate and graduate work in gas engineering at the Johns Hopkins University. For the 38 years since graduation I have been active in research, teaching, and plant operations in the fuel field. This work has been done in industry (Baltimore Gas & Electric Co., and in my present position as corporate scientific adviser to Texas Eastern); in Government (U.S. Bureau of Mines); and in the university (Illinois Institute of Technology and its affiliate, the Institute of Gas Technology). I was chairman of the panel on fuel science and technology under the Mineral Science and Technology Committee of the National Academies.

It is in connection with the findings and recommendations of the fuel science and technology panel report along with my own observations resulting from a long association with the field that I welcome the opportunity to testify briefly concerning the need for establishing in each State a research and training center that is devoted specifically to mineral science and technology including fuel science and technology.

The field of fuel science and technology embraces basic and applied research as well as commercial developments associated with the

analysis, properties, reactions, processing, distribution, and ultimate use of primary and processed fuels. The specific areas covered are:

1. Combustion of solid, liquid, and gaseous fuel in, for example, large central station boilers, in furnaces and other heating devices and in internal combustion and jet engines. A corollary to all of this work is the reduction or elimination of pollutants in the products of combustion.

2. Conversion of raw fuels to desired forms of energy. This includes, for example, refining of crude petroleum, conversion of solid fuels to liquids and gases. Obviously combustion is an important conversion step in the generation of electricity which along with liquid and gaseous fuels constitute the only forms of end use energy desired by the great majority of ultimate consumers today.

3. Metallurgical use of fuels in the blast furnace and other metal reduction and processing operations.

4. Nonfuel uses as, for example, the production of plastics, organic chemicals, and ammonia from coal, petroleum, and natural gas.

This brief summary of the scientific and technological areas encompassed by fuel science and technology emphasizes the importance of this field to our energy-based economy. We hear so much today of the energy crisis, or as I prefer to call it the energy crunch. I say crunch because we are caught in the pincers of environmental and ecological considerations on the one hand and the burgeoning demand for economical supplies of energy on the other. These diametrically opposed forces will eventually be coalesced in some middle ground through technological developments to which the individuals trained in fuel science and technology will make significant contributions.

Where have these individuals come from in the past? There are perhaps six and certainly no more than a dozen universities in the United States that emphasize fuel science and technology either as a separate discipline or as a major option in another discipline.

Obviously all of the individuals working in fuel science and technology today could not have been educated at these few universities. Since fuel science and technology is truly an interdisciplinary field in which physics, chemistry, and chemical and mechanical engineering are the major scientific and technological components, it is known that many of today's fuel scientists and technologists have come from the fields just mentioned and been given on-the-job training in the fuel field.

It is certainly true that we have made this system work after a fashion. But how much better it would have been if we had had a broad-based university research and educational program. The fuel industries would not have had to convince individuals from other disciplines that there are challenging problems in the fuel field. The man educated in this field in the university would already know this.

If in the past there had been broader support of fuel science and technology in the universities, we would have known, for example, more about the conditions under which pollutants are formed and could have used this information to control or eliminate them. Also, we would have been further along in the development of processes for converting coal and oil shale to liquid and gaseous fuels.

I see in S. 635 a real opportunity to rejuvenate the various areas encompassed by mineral science and technology. It is clear from the Mineral Science and Technology Report of the National Academies

that these areas are vital to our economy. It is also clear that we are not attracting young people to these areas of study. Part of this is undoubtedly due to the glamour associated with some of the new and more sophisticated areas of science and technology. But part of the problem is due to a lack of knowledge of the importance of mineral science and technology and the difficult and challenging problems that it faces.

How better can we combat this knowledge gap than by directing attention to this important general field by establishing in each State a research and educational institute that devotes all of its efforts to the advancement of mineral science and technology? Although these last comments relate to the general field, they apply equally to the field of fuel science and technology which will greatly benefit by this important program.

Thank you for the opportunity to present my views to the committee. I will be happy to respond to any questions that you may have.

Senator Moss. Thank you, Dr. Elliott, for your fine statement. Coming as you do from the fuel and energy branch of mining and minerals, I am glad to have your statement here. In your statement you indicated that perhaps one of the factors in our rather slow development of the technology to convert some of our solid fuels to liquid or gaseous fuels would have been answered had we had important research going on in a number of our institutions.

This always causes me to prick up my ears because I come from a State where we have vast beds of oil shale and for years we have been hoping in some way or other to get that shale converted to liquid petroleum or gas for use. So far we haven't been able to develop that and there hasn't been enough economic incentive to have perhaps a full-scale program of research so what we ought to do is have perhaps the academic research going on as to how this could be accomplished.

Would this be an example of what you are referring to?

Dr. ELLIOTT. Yes, I believe the new ideas, the innovative concepts for processing oil shale or other fossil fuels would have to come from the university. I think they would do the basic research that would point the way for new approaches for the applied research people to pick up and develop.

Senator Moss. Beside the lack of economic incentive you have indicated there is a dearth of highly trained personnel in the fuel field now. Most of them you have had to train sort of on the job as it were as they came over from other disciplines.

Dr. ELLIOTT. I think the people who came over from other disciplines and have stuck with the technology are really highly trained people. I didn't mean to infer the only person who could work in this industry are those who were originally trained. But I did indicate that those people who were educated stuck with the field to a much greater extent than those people who came in and even though they were given on-the-job training they seemed to drift off into other areas quite frequently.

Senator Moss. We thank you for your testimony and your expressed support for the legislation before us.

Senator Bellmon.

Senator BELLMON. I would like to ask Dr. Elliott a couple of questions. Is there at the present time much sharing of information between private industrial concerns in the energy business?

Dr. ELLIOTT. I can speak of one group, the gas industry as the Institute of Gas Technology which has done a great deal of the basic research for example on coal gasification. This isn't the only one, this is now being picked up by the Office of Coal Research and there is a large pilot project.

I think bituminous coal research has done a great deal of coal research and in this case it is in the field of coal gasification, that is the field I am familiar with. This is done on an industry-supported basis and is also being picked up by the Government through the Office of Coal Research.

I think the consolidation of coal has been working with the Office of Coal Research on both liquefaction and gasification processes. So I think to the extent these new technologies have come into being, they have been shared by some of the universities. That would be my assessment.

Now, there are certain areas where the information is proprietary in the fuel field that are not in the public domain.

Senator BELLMON. It has been my observation, and I was practically raised in an oil patch in Oklahoma, that because of the secret nature there has grown up in the industry a kind of reluctance to share information. It is almost as if you have your own CIA operation in each of the companies. Do you think this has been breaking down to some extent?

Dr. ELLIOTT. I can only speak about the gas industry which I know and have been associated with and because it is a regulated industry the importance of proprietary information is not as great because everybody will share. The distribution and pipeline companies support research and it is made generally available. I would not care to comment on the conduct of any other industries with which I have not had so much direct contact.

Senator BELLMON. Well, Dr. Boyd in his statement earlier pointed out that some of the technology that the Cooper Range Co. has developed is now being used by the mines industry. It occurred to me that possibly the passage of this legislation and the creation of the type of centers we are talking about might encourage a greater interaction between the different companies and perhaps make some of the knowledge that is now considered to be proprietary a little more generally available.

It seems to me that might be one of the major advantages to this kind of legislation.

Dr. ELLIOTT. I think that is a very good point because I think these institutes would constitute a meeting ground for various companies that had mutual problems and I think your point is well taken.

Senator BELLMON. There is one other point I would like to raise. I have been impressed over the years with the tremendous benefit that not only agriculture but this entire country has had because of research work being done by the land-grant colleges in the field of agriculture.

We are now feeding our population with fewer than 5 percent of our manpower actually involved in agriculture production where many countries like Japan still have from 30 to 40 or 50 or even a greater percent of their people involved in agricultural production for the simple reason they haven't been able to develop the technology we have here.

This has been a Government technology to develop the technology and make it available to them for private users to apply it for the general welfare. It seems to me the mineral industry might gain the same kind of results if we were able to do the same sort of thing in this field that has already been done in agriculture.

Do you feel this is a reasonable expectation?

Dr. BOYD. I for one do, Senator.

Dr. ELLIOTT. I agree.

Dr. MARZKE. So do I.

Senator MOSS. Thank you gentlemen for your appearance. You have given us good information for our record. I am now going to ask Mr. Herbert S. Richey and Mr. Roger Haynes to come forward as the next panel. Mr. Richey, would you like to go first?

Mr. RICHEY. Yes, sir.

STATEMENT OF HERBERT S. RICHEY, VICE CHAIRMAN OF THE BOARD, NATIONAL COAL ASSOCIATION, AND PRESIDENT, VALLEY CAMP COAL CO.

Mr. Chairman, thank you very much. My name is Herbert S. Richey and I am from Cleveland, Ohio. In addition to being president of the Valley Camp Coal Co., I am currently the vice chairman of the National Coal Association. I appear here today on behalf of my company and the association to express strong support for S. 635.

Accompanying me is Mr. Roger M. Haynes, director—employee relations, for Consolidation Coal Co. Mr. Haynes, because of his extensive experience in personnel recruiting, will tell the committee more about the details of the need for this legislation.

I would like to indicate that Mr. Haynes and I have coordinated our testimony and I have dropped out some of my testimony which I understand will be included in the record.

Senator MOSS. That is right.

Mr. RICHEY. The coal industry today faces unprecedented challenges. For one thing it must comply with the extreme requirements of the Mine Health and Safety Act which became effective just over a year ago. I say extreme because many requirements of that act are in advance of current technology and in advance of the technical abilities of the mining and safety personnel available today.

In addition to technical problems which must be solved relating to underground mining, the coal mine industry is also confronted with demands for stricter controls over surface mining, and even more stringent regulations over the burning of coal.

As the demand for coal increases, and as the regulations under which it is produced and used become more stringent, there is obviously a need for more technically trained personnel, particularly qualified engineers and safety experts. Their skills are more in demand today than ever before and the need for such personnel will continue to increase.

Yet we are confronted with a situation in which the number of colleges and universities with accredited departments of mining engineering are declining, and the number of degrees granted in mining engineering are falling off rather rapidly.

I fear, Mr. Chairman, that this situation has been unrecognized for too long; hence the necessity for this important legislation which would encourage more young men, and even women, to consider a future career in the coal mining and related industries.

Establishing appropriate research and training centers in the States and providing funds for research in areas related to the production and use of our natural mineral resources, including coal, will attract qualified teachers who in turn will stimulate potential students to enroll.

Without strong support from the Federal Government, I feel sure there will be a further decline in the number of accredited mining engineering departments and an almost certain decrease in the number of graduates with degrees in mining engineering.

Dr. Elburt Osborn, the Director of the U.S. Bureau of Mines, has pointed out the parallel between our dependence on mineral resources and agricultural resources. In the case of agriculture, Federal and matching State funds are regularly appropriated for research purposes. This has led to a continuous supply of men trained to deal with agricultural problems.

Unfortunately we have no comparable program for mineral resources, despite the fact that our mineral resources provide the raw materials for our mills, factories, and powerplants. In fact, I cannot think of any product or service that exists today that in some way does not originate from a mineral resource or process, and yet all of the mineral industries are in trouble for a variety of reasons. We find ourselves in this crucial period with a shortage of trained technical personnel.

Many, if not most of the management positions in the coal industry today are occupied by men who have been trained in engineering. There are several routes the graduate engineer may travel toward the executive level in a coal company. From a starting salary of perhaps \$850 to \$1,000 per month, the graduate engineer may advance through the engineering, mine operation, safety and research, and possibly even sales functions.

His salary and other benefits will normally increase until he may well become a highly paid corporate executive. The emphasis on improved technology means that many management positions of high responsibility will continue to be occupied by men with special engineering skills.

Coal production has been increasing and it must continue to do so in the future if the Nation's demands for energy are to be met. Coal is by far our most abundant fuel resource. According to U.S. Geological Survey estimates, it constitutes more than 80 percent of our proven fuel reserves.

On the other hand, our reserves of natural gas and petroleum are severely limited. Known reserves of gas, our most critical short fuel, are expected to be exhausted before the year 2000; hence many experts indicate that methods for converting coal into pipeline quality gas will be required before the end of the next decade.

The situation with liquid fuels has not reached the same critical stage as has gas. One reason for this is that the Federal Government has had its hand on the spigot which controls foreign oil imports. Recent history indicates that when the domestic oil supply gets a little tight, the Government opens the spigot a bit wider.

But that situation may be changing, for as we have seen in the past several months, foreign governments have been more inclined to take a firmer position in making their petroleum supplies available to us. Further, many Americans, particularly those on the east and west coasts, are distressed by their dependence on unreliable foreign oil as their principal source of energy. In any event, we know that the domestic supplies of gas and oil cannot continue to meet our needs indefinitely. This will put additional pressure on the coal industry to supply coal for gasification and liquefaction.

Special skills, acquired only through technical training, will be required to meet the new burdens which will be placed upon the coal industry. The enactment of legislation along the lines of S. 635 will help to meet this need. We urge its approval at the earliest possible date.

I would like to interject here that last June I was a member of a nine-man team of Americans who visited the Soviet Union. We were the first official delegation of coal experts ever to visit the Soviet mines. During our trip we visited the research institute at Bekievka, about 20 miles from Jenevietz, a coal mining center.

I think our whole delegation was really rather impressed with the research and educational facilities at these institutes. I think the Soviet Union is ahead of us in this matter, particularly in the lines of methane detection, monitoring, and dust control and dust analysis.

I just interject this to emphasize our personal feeling at the Coal Association as to the need of this type of bill.

Senator Moss. Do you know how many such institutes they have in the Soviet Union?

Mr. RICHEY. No; I do not. We visited two; there may be one more. The main one we visited at Bekievka has about 1,500 people employed there. They had outgrown their campus-like facilities and were hoping in the new plan or budget, the new 5-year plan just announced, to be able to build new and larger facilities.

It was interesting to see how they operated. I might also say that the Soviet Union thought they could depend on natural gas internally and oil internally for fuel. They let the coal industry slide down in fact, they closed their mines in the national coal basin.

Like ours they found out coal is the future fuel and they appropriated in the new plan \$1.5 billion to expand their coal production by 200 million tons. As you may know, Senators, they are now the largest coal producers in the world.

Senator Moss. I am aware of the vast coal reserves there and sometime ago there were general figures on the number of engineers being graduated from Soviet schools and universities as compared with ours and they were outnumbering our graduates by a rather large margin. I don't remember any breakdown into mining and fuel engineers but over the whole engineering field they are outstripping us by large margins.

Mr. RICHEY. Yes; although our experience taught us that people they call engineers are not as highly qualified as we thought our graduate engineers were. They include in engineers certain clerical people, draftsmen, assistant mine foremen, and so on. So I think from an educational standpoint a graduate mining engineer in this

country has a superior education to many of the engineers the Soviets claim.

A great deal of their training is of a vocational nature.

Senator Moss. And I am sure there is a difference in perhaps what the term means from one country to another. But the thing we ought to learn from and profit by is the Soviet emphasis on establishing the institutes where this sort of training is given where ours seem to be declining.

Mr. RICHEY. This is very correct, and they are emphasizing this and doing a very fine job of it. If I may, now, I would like to turn our testimony over to Mr. Haynes, director of personnel of Consolidated Coal.

(Mr. Richey's complete statement follows:)

STATEMENT OF HERBERT S. RICHEY, PRESIDENT, THE VALLEY CAMP COAL CO.

Mr. Chairman and Members of the Subcommittee, my name is Herbert S. Richey and I am from Cleveland, Ohio. In addition to being President of The Valley Camp Coal Company, I am currently the Vice Chairman of National Coal Association. I appear here today on behalf of my company and the association to express strong support for S. 635. Accompanying me is Mr. Roger M. Haynes, Director-Employee Relations for Consolidation Coal Company. Mr. Haynes, because of his extensive experience in personnel recruiting, will tell the Committee more about the details of the need for this legislation.

The coal industry today faces unprecedented challenges. For one thing it must comply with the extreme requirements of the Mine Health and Safety Act which became effective just over a year ago. I say extreme because many requirements of that Act are in advance of current technology and in advance of the technical abilities of the mining and safety personnel available today. In addition to technical problems which must be solved relating to underground mining, the coal mine industry is also confronted with demands for stricter controls over surface mining, and even more stringent regulations over the burning of coal.

As the demand for coal increases, and as the regulations under which it is produced and used become more stringent, there is obviously a need for more technically trained personnel, particularly qualified engineers and safety experts. Their skills are more in demand today than ever before and the need for such personnel will continue to increase.

Yet we are confronted with a situation in which the number of colleges and universities with accredited departments of mining engineering are declining, and the number of degrees granted in mining engineering are falling off rather rapidly.

I fear, Mr. Chairman, that this situation has been unrecognized for too long; hence the necessity for this important legislation which would encourage more young men, and even women, to consider a future career in the coal mining and related industries. Establishing appropriate research and training centers in the states and providing funds for research in areas related to the production and use of our natural mineral resources, including coal, will attract qualified teachers who in turn will stimulate potential students to enroll. Without strong support from the Federal government, I feel sure there will be a further decline in the number of accredited mining engineering departments and an almost certain decrease in the number of graduates with degrees in mining engineering.

I cite here an example that has occurred affecting my own company. Because of the high degree of technical training and the complete all around education they obtained, my company in the past employed a number of mining engineering graduates from Lehigh University; so many that one of them jokingly suggested that we change the name of the company from The Valley Camp Coal Company to The Lehigh Valley Camp Coal Company. But this source of engineers is no longer available to us since Lehigh no longer offers a degree in mining engineering. In fact, to my knowledge only four or possibly five universities east of the Mississippi River offer degrees in mining engineering.

Dr. Elburt Osborn, the director of the U.S. Bureau of Mines, has pointed out the parallel between our dependence on mineral resources and agricultural resources. In the case of agriculture, federal and matching state funds are regularly appropriated for research purposes. This has led to a continuous supply of men trained to deal with agricultural problems.

Unfortunately we have no comparable program for mineral resources, despite the fact that our mineral resources provide the raw materials for our mills, factories, and power plants. In fact, I cannot think of any product or service that exists today that in some way does not originate from a mineral resource or process; and yet, all of the mineral industries are in trouble for a variety of reasons; we find ourselves in this crucial period with a shortage of trained technical personnel.

Many, if not most of the management positions in the coal industry today are occupied by men who have been trained in engineering. There are several routes the graduate engineer may travel toward the executive level in a coal company. From a starting salary of perhaps \$850 to \$1,000 per month, the graduate engineer may advance through the engineering, mine operation, safety and research, and possibly even sales functions. His salary and other benefits will normally increase until he may well become a highly paid corporate executive. The emphasis on improved technology means that many management positions of high responsibility will continue to be occupied by men with special engineering skills.

Coal production has been increasing and it must continue to do so in the future if the nation's demands for energy are to be met. Coal is by far our most abundant fuel resource. According to U.S. Geological Survey estimates, it constitutes more than 80 percent of our proven fuel reserves. On the other hand, our reserves of natural gas and petroleum are severely limited. Known reserves of gas, our most critically short fuel, are expected to be exhausted before the year 2000; hence, many experts indicate that methods for converting coal into pipeline quality gas will be required before the end of the next decade.

The situation with liquid fuels has not reached the same critical stage as has gas. One reason for this is that the Federal government has had its hand on the spigot which controls foreign oil imports. Recent history indicates that when the domestic oil supply gets a little tight, the government opens the spigot a bit wider. But that situation may be changing for, as we have seen in the past several months, foreign governments have been more inclined to take a firmer position in making their petroleum supplies available to us. Further, many Americans, particularly those on the east and west coasts are distressed by their dependence on unreliable foreign oil as their principal source of energy. In any event, we know that the domestic supplies of gas and oil cannot continue to meet our needs indefinitely. This will put additional pressure on the coal industry to supply coal for gasification and liquefaction.

Special skills, acquired only through technical training, will be required to meet the new burdens which will be placed upon the coal industry. The enactment of legislation along the lines of S. 635 will help to meet this need. We urge its approval at the earliest possible date.

In closing the thought comes to my mind that you may be asking yourselves— all right, Mr. Richey, you're here to support S. 635, but how would its passage affect your company and how would you take advantage of the increased facilities and opportunities for mining education which the bill would provide?

Gentlemen, all of my company's mines are located in West Virginia; periodically we visit local high schools near our mines where we talk to students in assembly, show them movies produced by the National Coal Association, and talk to them about mining. This is followed by an invitation to visit our properties, engineering departments, shops, coal preparation plants, and underground mines.

To cite a specific example, we recently put on such a program at a high school in Wheeling, West Virginia. As a result of the assembly program, twenty students visited us and seven indicated a desire and interest to study mining. I was told as late as yesterday morning that two more have shown sufficient interest to work for us this summer and then enroll at West Virginia University to study mining. Believe me, West Virginia University is an excellent mining school, but it is the only one available in that part of the country. It is my feeling that passage of S. 635 would permit more students to attend more schools, and thus produce a more varied educational experience which my company and certainly the industry badly needs.

I appreciate the opportunity to appear before this Committee and present my views on this important legislation. I will now ask Mr. Roger Haynes, Director, Employee Relations, Consolidation Coal Company, to continue this presentation endorsing S. 635.

Senator Moss. We look forward to hearing from Mr. Haynes.

**STATEMENT OF ROGER M. HAYNES, DIRECTOR, EMPLOYEE
RELATIONS, CONSOLIDATION COAL CO.**

Mr. HAYNES. I am Mr. Haynes, director of employee relations of Consolidation Coal Co., headquarters in Pittsburgh. I appear here today along with my colleagues in the coal industry to urge this committee to approve S. 635, which recognizes the need for significant Government support in areas of research, investigations, and experimentations, as well as for the training of scientists, engineers, and technicians in coal mining, coal mining safety, health of the coal miner, coal mined land reclamation, and other associated activities related to the coal industry.

Coal makes up 80 percent of our Nation's proven fuel resources—reserves that are estimated at anywhere from 800 billion to more than 1 trillion tons. Total U.S. coal production in 1970 was 595 million tons. Based on a combination of Federal Power Commission reports and our company's internal energy studies, coal production for 1971 is estimated at 615 million tons. For 1975, 680 million tons. For 1980, 770 million tons. And for 1985, coal production is estimated at 860 million tons.

Many things could happen which would require the growth of our industry to be even greater. Short supplies of natural gas and petroleum products, delays in nuclear energy power facilities, and so forth, would increase the demand for this natural resource of proven reserves.

Our dilemma is this: at a time when the demand for coal is ever increasing as an energy fuel for electrical, steel and other industrial markets, the supply of competent research scientists, trained engineers and technicians needed to improve production techniques, to solve problems of health and safety, to solve problems of land reclamation and environmental control, is simply not available today. Not only are these areas of vital importance neglected, but there also are insufficient mining engineers and technicians to take care of the growth of present mining activities.

Only 20 colleges and universities in the entire United States offer undergraduate degrees in mining engineering or related areas.

Last year 132 mining engineers graduated from these universities. It is anticipated that 148 will graduate this May, with an estimated 14 additional at the end of the summer term. By this year's end, there will have been only 184 graduating nationwide during 1971, and I refer you to table 1.

We have just this past week completed a study of mining engineering enrollments at the 20 universities offering a mining curriculum. The current total or enrollments, nationwide, including advanced degree students, is only 992.

Based upon the engineer student retention percentages published in the Engineer Manpower Bulletin, April 1967, the maximum number of mining engineers that can be expected to graduate with bachelor of science degrees in the 5-year period 1971-1975 is 722.

To put this supply of mining engineers into some type of perspective, please refer to table 2. My company at the present time has a percentage ratio of technically trained manpower to total manpower of 2.6 percent. If you were to assume that this percentage was about

right, even though we believe it to be far too low, and project it for the entire coal industry, the total number of technically trained people in our industry today is 3,340.

Just to maintain the status quo, a net increase of 85 are needed each year. When this is combined with a conservative estimate of 5 percent leaving the industry each year due to joining mine machinery manufacturers, mine service organizations, Government agencies, retirement, death, and disability, the requirement this year is 252 engineers, 257 next year, 261 during 1973, 265 during 1974, and 269 during 1975. By 1980, 293 will be needed annually, and this increases to 318 annually by 1985.

As you can see, if no bachelor-level graduates were to enter graduate school, if none were to enter the military service, if none were to join the Bureau of Mines or other Government agencies, if none were to join equipment design firms or manufacturers, if none were to enter copper, lead, zinc or other mining fields, and all joined coal mining firms this year, the demand would exceed the supply by 68 men.

The number to be graduating through the year 1975 is already determined, and the 5-year demand exceeds the 5-year supply by 582 men.

Obviously, engineers from other disciplines such as mechanical, civil, electrical, and industrial engineering must be encouraged to join the mining industry.

The serious shortage of mining engineers has been caused by several factors:

First, because of the general public impression that nuclear energy would replace coal as an energy source in power generation, the public felt that the importance of the coal industry had declined.

Second, an unawareness of opportunities in mining engineering at the high school level. Many students, and even their counselors, have not been familiar with the mining engineering curriculum.

Third, some young men shy away from a career in coal mining because of poor health and safety records, as well as environmental conditions over the years.

Fourth, due to lack of funds and interest, the mining schools are weak in the areas of research. As a result, their ability to attract top quality research scientists and professors has suffered.

Fifth, because of the drop in enrollment and increased costs of education, some mining schools have closed. Only 20 schools now offer courses in mining, and some of these are in combination with other disciplines.

We in the coal industry have taken measures in order to attract more young men, and women, to the coal technology field through research grants and scholarships to mining schools, and through university summer employment and co-op programs. We are also actively conducting educational campaigns in the high schools. But we feel as though we are on a treadmill.

In order to stimulate the interest of hundreds or even thousands of research and production-oriented engineers and technicians needed to solve this industry's problems, I believe it will take a Federally supported program, as proposed in this bill, S. 635.

Such research and training centers at State universities would offer a challenge to the research, health, safety, and environmental experts who would teach at these centers. These knowledgeable professors

would, in turn, attract more young men and women to mining engineering through a more meaningful and more specialized curriculum.

This industry recognizes that we have the responsibility to attack and solve the technical problems relative to safer coal mines, healthier coal mines, improving working conditions in the mines, and feasible ways of controlling the environmental problems created in the mining process.

This industry recognizes the need for the Bureau of Mines to utilize technically trained inspectors in the enforcement of the Federal Coal Mine Health and Safety Act. I mention these facts in order to strengthen the reason for our appearance here today.

The proposed research and training centers in each State could, because of their twofold purpose, enable mining engineers to specialize and therefore be more valuable to industry. Today, for example, in our mining research function, we do not have one active mining engineer who is a specialist in rock mechanics, or computer simulation, or exploration. We are unable to hire a mining engineer with interest in equipment design. We do not have enough engineers to draw on with advanced degrees.

It is felt that the proposed centers would also give the engineer adequate time in order to follow through on specific research projects. One of the biggest problems in the current method of conducting research in universities is that research is of short duration. An engineer preparing his thesis works in highly theoretical areas, and his research is done on a small scale in a laboratory or library. In most cases, he does not receive any practical experience in a productive mine. If a student could get academic training plus field research and application, he would have a more positive direction upon graduation. He would be better qualified to make a significant contribution to coal technology.

In the area of health and safety in mining, industry is devoting much of its expertise in arriving at solutions to problems, but again, because of the lack of sufficient trained technicians we are not able to progress as rapidly as we must in order to provide a more productive environment in which to work.

More technicians are needed for:

The study and evaluation of roof control systems, including more specialization in rock mechanics.

The study of mine ventilation systems, including degasification and dilution of methane gases.

Fire prevention controls and alarms.

Respirable dust control.

Study of noise levels.

A study of safety involved with equipment. For example, the new Health and Safety Act requires protective canopies over equipment. Engineers are needed for the development of these systems.

More technicians are needed to assist current projects on the degasification of the coal seam before mining.

Much research effort should be directed toward the devising of new mining techniques that would provide not only safer, healthier working conditions, but also sufficient production to satisfy the Nation's requirements in the future.

Developments such as remote control mining, continuous haulage, temporary roof support that is movable, indestructible mining machines, hydraulic mining, and transportation, must be perfected.

One of the most basic research areas in which additional mining engineers are needed is the development of selective mining techniques. Experiments are currently being conducted at Pennsylvania State University, supported by the Office of Coal Research, in which they are making investigations of the petrographic components of coal. In breaking down these components, research experiments can determine which portions of specific coal seams are best suited for utilizing the coal for coking, pipelines, conversion into gasoline or gas, and so forth.

We do not have adequate knowledge in this area and are therefore handicapped in that we are not taking advantage of the coal material we bring above ground to the extent we should. Selective mining techniques can develop better production processes, more efficient preparation plants, and can create an entirely new area of new product uses for coal.

Work underground has to be better coordinated with work above ground. Improved production methods, better ways of preparing coal for market, efficient health and safety measures, environmental controls, all are related for the coal industry to continue as a major supplier of energy fuel. The Nation must have this energy fuel.

Today's mining operations are hampered by a shortage of adequate research facilities and trained technical people. We are so involved with day-to-day problems that there is not much time to devote to long-range mining needs.

In closing, Mr. Chairman, let me repeat that the coal industry recognizes the serious need for the establishment of mineral resource research and training centers in the United States. With the supportive technology and the additional pool of expertly trained mining engineers to be provided, we can come up with lasting and effective solutions that will help the coal industry to fulfill the burgeoning energy demands of our Nation.

Mr. Chairman and members of the subcommittee, I appreciate the opportunity to present these views of the coal industry, and urge that you support this bill, S. 635. I shall be most happy to respond to any questions.

(The tables referred to follow:)

TABLE I

I. Mining engineering enrollments—1970-71 school year:	
Freshman.....	231
Sophomore.....	229
Junior.....	210
Senior.....	222
Graduate.....	100
Total students.....	992
II. Mining engineering scholarships available—287.	
III. Projected mining engineers graduating with B.S. degree:	
1971.....	184
1972.....	166
1973.....	154
1974.....	111
1975.....	107
Total, 5 years.....	722

Projected graduating students based on engineer student retention percentage, Engineer Manpower Bulletin—April 1967.

TABLE II.—TECHNICALLY TRAINED MANPOWER IN BITUMINOUS COAL INDUSTRY

	1971	1972	1973	1974	1975	1980	1985
Consolidated current ratio—2.6 percent of total technically trained manpower.....	3,340	3,425	3,510	3,595	3,680	4,170	4,660
Number of technically (5 percent) trained men leaving industry annually—death, suppliers, Government.....	167	172	176	180	184	208	233
Number of technically trained men required (demand).....	252	257	261	265	269	293	318
Supply: Estimated number of graduating mining engineers (U.S. citizens).....	184	166	154	111	107	(?)	(?)

Senator Moss. Well, thank you very much, Mr. Haynes. That is a well worked out and detailed statement. You are calling for the number of mining engineers that we fall short of and will continue to fall short of in the years ahead. This is a convincing argument for establishing this type of research support in our universities and colleges. I think all of us are aware now of the increasing, galloping demand for energy in this country and that is centered to some degree on coal now because we see the reserves dropping in gas and not growing very much in liquid petroleum, so coal is one of our cheap sources of energy that we look to in the years ahead.

So your presentation of this from the angle of coal mining and the problems that we have in coal mining to be solved is a great value to us. You didn't spend a great deal of time talking about pollution problems and how much research needs to be done there. Isn't this a whole area that must have a great deal of research done, the control of air pollution from the use of coal and fuel?

Mr. HAYNES. Yes, it certainly is. As a coal mining company our problems on pollution are directly related to the acid mine drainage and the health and safety activities and the land reclamation area. The power industry—and of course it relates to us very significantly—has this problem of air pollution as a result of burning the coal.

Senator Moss. This committee in about 2 weeks is going to hold some hearings in the Four Corners area. Because of the large power-plants being built there we are concerned with pollution, air pollution, fly ash, and gases given off from the stacks. I wish I knew what the answer was or how pollution could be controlled and still utilize the energy from the coalfields in these rather remote locations.

These plants are not near any cities. They are in a very remote location but it is scenic and beautiful and we just cannot have it polluted.

Mr. HAYNES. We are vitally concerned in the answers, too, and it really comes from research and technological development.

Senator Moss. We certainly appreciate the testimony you have brought to us for our record today. I should again make a general announcement that this record is going to be open for 30 to 60 days until we complete the report of the Department.

If there are additions that any witnesses would like to put in the record, you can send it to us in writing and we will have it inserted any time within the next 30 days. Thank you very much.

Mr. HAYNES. Thank you.

Senator Moss. We have a rather large panel and we are pleased to have these distinguished men with us, Dr. Thomas Bates from Pennsylvania State, Dr. Beistline from Alaska, Dr. Joseph Pask from the University of California, Berkeley, Dr. Theodore J. Planje, School of Mines, University of Missouri, and Dr. John C. Ludlum, Dean of the Graduate School, University of West Virginia.

We are pleased to have you gentlemen with us and we look forward to hearing your testimony. As I indicated before, the full text will be in the record and you may, if you wish, summarize or select particular passages that you want to emphasize for the committee.

We are glad to have you. We will hear first from Dr. Thomas Bates, vice president at Penn State.

STATEMENT OF DR. THOMAS BATES, VICE PRESIDENT FOR PLANNING, PENNSYLVANIA STATE UNIVERSITY, UNIVERSITY PARK, PA.

Dr. BATES. Senator Moss, it is a pleasure to be here again testifying before you. I am vice president and professor of mineralogy of Pennsylvania State. I appear before you as chairman of the Committee on Mineral Resources of the National Association of State Universities and Land-Grant Colleges.

I am accompanied by four of the members of this nine-man committee, namely, Dr. Earl H. Beistline, dean, College of Earth Science and Mineral Industries, University of Alaska; Dr. John C. Ludlum, dean, Graduate School, West Virginia University; Dr. Joseph A. Pask, assistant dean, College of Engineering, University of California, and Dr. Theodore J. M. Planje, dean, School of Mines and Metallurgy, University of Missouri.

Together we represent over 100 State universities and land-grant colleges that are the member institutions of the National Association. We are here today in behalf of these institutions to express strong support of bill S. 635. The panel before you is constituted in a manner designed to represent the great variety of mineral resource problems of our States and some of the subject matter areas most involved in their ultimate solution. Each of us is prepared to present a brief statement and answer any questions you may wish to ask.

All of us who have been closely associated with mineral science and technology have been well aware of trends in the mineral resource field which, should they be allowed to continue, jeopardize the future domestic economy and the international security of our country.

Documentation in support of this statement is effectively presented in the recent report of the National Academy of Sciences on "Mineral Science and Technology: Needs, Challenges, and Opportunities." And, indeed, the very promulgation of bill S. 635 is eloquent testimony that action at the national level is called for and Federal leadership is required.

Our committee commends the Senate Committee on Interior and Insular Affairs for its leadership and supports the recommendation to the effect that the Secretary of the Interior be charged with the administration responsibilities for which the bill provides.

The major provision of this bill, namely, "the establishment of an appropriate research and training center in each State," is considered by our committee to be the most important initial step that can be taken in effectively tackling our national mineral resources crisis.

Two specific examples of the problems facing us may be used to illustrate the particular suitability of going to the mining schools, state universities, or land-grant colleges for all-out support of a national effort. At the present time, the fraction of U.S. metal re-

quirements obtained from abroad is almost always appreciable and often very large. For copper it is about 30 percent; for lead 33 percent; for zinc 60 percent; for iron ore over 33 percent; for nickel about 90 percent; for manganese almost 100 percent; for chromite essentially 100 percent; for mercury slightly less than 40 percent; and for platinum over 90 percent.

The purchase of all these metallic raw materials causes a sizable addition to our unfavorable balance of payments, and our failure to produce them here results in a loss of jobs for American workers. I think the unfortunate thing is we have mines, as you well know, all over this country that have not been completely exploited that still have these materials in them and we believe appropriate research can enable us to produce these materials at a price that will compete with the foreign products.

Nevertheless, exploitable deposits of these metals have been known in this country in the past, and indeed the Nation abounds in examples of mines that, though far from exhausted, have been shutdown because they cannot compete with the products of foreign deposits.

Obviously, this has been done because these mines cannot make a profit with the methods in use and the prices paid. Successful research in many instances might put these mines back on a paying basis. Examples include: (1) the hematite mines of the Birmingham, Ala., district; (2) the magnetite mines of the Dover, N.J., area; (3) most of the fluorite mines of the Southern Illinois-Kentucky fluorspar district; (4) the tungsten mines of Nevada such as Mill City, Oreana, and Silver Dyke and the inactive mines of the Bishop area that lies on both sides of the Nevada-California line; (5) the copper deposits of eastern Vermont; (6) the copper deposits of the Foothills belt of California; (7) the chromite mines of Oregon; (8) the closed primary iron mines of the various districts of the Lake Superior area; (9) the tungsten mines in northern North Carolina; (10) the gossan lead of western Virginia; (11) the lead-zinc mines of central Pennsylvania that have not been worked since just after the Civil War; (12) the iron mines of northern New York State; (13) the zinc-lead mines of southwestern Wisconsin and northwestern Illinois; and (14) the anthracite coal mines of Pennsylvania.

Most of the research work to be done on such deposits as these would be in the disciplines of mining and mineral beneficiation, but in numerous others the problems lie in the field of extractive metallurgy. For example, at the Sanford Lake iron-titanium mine in central New York State, huge tonnages of magnetite concentrates that are too high in titanium to be used in the production of pig iron and too low in titanium to be titanium ore are now stockpiled. A method of separating these two elements would release valuable amounts of both.

A second type of mineral resource problem area is illustrated by our Pennsylvania anthracite situation. Here, where we have one of the highest concentrations of some of the best coal in the entire world, up to 50 percent of it—in much of the region—is not recoverable by present mining methods.

A similar situation exists in the bituminous region of Pennsylvania, West Virginia and, indeed, most of our coal-producing States. Furthermore, our coal reserves are literally an unknown warehouse of other valuable metals, as for example tin, germanium, and uranium, all of

which are now literally going up in smoke or piling up in fly ash or mine refuse. We will not be making effective use of this tremendously important natural resource until we—

1. can get it out of the ground without the present hazards of underground mining, surface subsidence, and mountains of waste;
2. can recover all the mineral values from it;
3. can develop more effective combustion processes;
4. can eliminate acid mine water in the streams and sulphur dioxide in the air;

The specific problems of our mineral industries are endless, but these examples illustrate major characteristics typical of most that make it evident why the research institute approach proposed in S. 635 can be extremely effective in their ultimate solution.

First, the example of our present import situation illustrates the national scope and significance of many of these problems. Our committee is here today representing a national association—one which has ably demonstrated in the area of renewable resources, agriculture, how effectively the universities of 50 States can work in concert for the solution of national problems.

Second, the example of unworked mines of differing character in various parts of our Nation, points up the necessity of the State-by-State approach where experts trained in the particular problems of varying ore types, varying geological conditions, and varying environmental conditions imposed by man and nature can apply their particular expertise to local conditions while at the same time contributing to the regional and national pool of knowledge.

Third, as illustrated by the coal example, modern mineral resource problems must be solved using a systems approach. No longer can the mining engineer do his thing without regard for the problems he may be generating for the metallurgist, mineral economist, pollution expert, or public at large.

Our State and land-grant universities are experienced in the interdisciplinary approach. The mineral resources institutes will bring together, from a variety of departments, those experts most capable of interacting on mineral resource problems. They will also be in close touch with and have available the professionals already working in our air environment centers, the water research institutes, the agricultural experiment stations, and numerous other interdisciplinary groups organized to work most effectively on the problems of our society in the true land-grant tradition.

Fourth, and probably most important, our mineral resource problems and their solution are different from those we have faced in the past. Words and phrases like recycling, solid waste, liquid extraction, rapid excavation, cost-benefit ratios, and underground storage, have only relatively recently become part of our working vocabulary.

New kinds of problems need new breeds of men. The graduate students that train in these institutes had better be good, because I don't think those of us in this room today can really appreciate the magnitude, technical, sociological, economic complexity of the mineral resources problems of 10, 20, 30 years from now, for they must be the leaders in facing mineral resource problems of a magnitude and a technical, economic, and sociological complexity that those of us here today can barely appreciate. It is the job of our universities to produce such men. These institutes will provide the vehicle which, with adequate support, will enable us to do so.

In concluding this statement, I would reiterate that our committee strongly favors the provisions made in S. 635. We would also highly recommend that consideration be given to two additional areas of possible support, which, if incorporated in the present bill, would in our opinion further increase its effectiveness.

Recognizing that experts in the mineral sciences and technology are in extremely short supply, we believe it would be very desirable to have a provision that would make contract and grant funds available to eligible professionals at all universities. Furthermore, we would consider most essential an adequate provision of funds to the institutions for use in attracting and properly supporting an increasing cadre of students to be trained in the solution of today's problems for facing the more complicated ones of tomorrow.

Thank you for the opportunity to appear before you and present this statement.

Senator Moss. We certainly appreciate your statement, Dr. Bates, and your outline of the problems we now have which need solution. Some national effort must be made to train the people who can do the research and attack the problems that we have. We complain about air pollution and know that we must solve it, and could probably find some value in that pollution if we just knew how to precipitate it out.

If we could get that sulfur out or tin or whatever else is going up the flue and poisoning plants and people it would be a valuable resource if we just knew how to do it. We don't know, at least economically, how to do it at this point. So we are in great need of research.

Dr. BATES. I can envisage plants 20 or 30 years from now that represent completely closed systems, where we don't ever let this stuff out until it is cleaned up to the point that we can use it.

Senator Moss. Yes. I think that has to come and it should be able to come for two reasons. One, to keep the air pure, and second seek to recover all of these materials that have some use and some value. In a sense this is the recycling we keep talking about. Recycle it by using appropriately. Well, thank you very much.

Dr. Beistline is professor at the University of Alaska. I know Senator Stevens wishes he were here now. He briefly introduced you before he had to leave.

STATEMENT OF DR. EARL H. BEISTLINE, PROVOST, UNIVERSITY OF ALASKA

Dr. BEISTLINE. Thank you, Senator Moss. My remarks will be abstracted from what I had prepared in written form and if there are any questions of course that come to mind, I would be very happy to attempt to answer them.

The Land-Grant College Act was adopted by the Alaska Territorial Legislature in 1915 and consequently the Alaska Agricultural College and School of Mines opened its doors in 1922 and provided the basis for the development of the University of Alaska (1935), the State's system of public higher education.

The success of bringing together basic support of academic instruction, research, and extension has been recognized by public institutions of higher education, many of whom have moved the triumvirate from the colleges of agriculture toward encompassing the offerings of the total university for greater service to the people.

Within the University of Alaska, and based upon the concepts of the original land-grant acts, have grown major research facilities in agriculture: Institute of Agricultural Sciences, U.S. Department of Agriculture cooperating with the University of Alaska, which has stations at College, Palmer, and Petersburg and a dynamic statewide program in cooperative extension service. The approximate total budget is \$2,178,299 for the 1971 fiscal year, of which 37.6 percent is Federal support.

By comparison, no Federal support has been available for mining research, instruction, or extension, the budget (statewide services) of which totals \$340,571. Both sets of figures do not include funding for specific research projects that may have been received.

The land-grant, Hatch, Smith-Lever and other related acts developed the most efficient and productive system of agriculture known throughout the world. This was fundamental in achieving for the United States the highest standard of living that mankind has ever known.

Similarly, Senate bill 635 has excellent objectives and through the field of mineral engineering will foster the wisest development and use of our minerals and metals to perpetuate and defend the benefits that have occurred to our society.

In much the same manner, the Sea Grant Colleges which are now coming into existence have for their objective the obtaining of knowledge about the sea and the utilization of the sea's resources for mankind. The program as originally conceived paralleled the procedure of the development of agriculture under the land-grant idea.

Specific reasons for supporting the bill are:

(1) The importance of minerals to the national interest of the Federal Government is clearly stated in the Mining and Minerals Policy Act of 1970 (Public Law 91-631) which this bill would amend.

(2) Predictions for the future indicate that larger quantities of minerals and metals will be needed because of their increasing per capita consumption and a growing population.

(3) Stimulating, dynamic, prestigious mineral engineering programs for the future must be adequately financed in order to train people for the production of minerals with comprehensive ecology, environment, and pollution control.

(4) In the recent past, because of small enrollments (111 graduates in mining engineering in the Nation in 1970) and increasing costs of university operations, the number of mining engineering programs has been reduced from 26 to 17 in the 5 year period 1962-67. This bill would provide funding that will allow mineral engineering teaching, research and extension departments to be revitalized with programs geared to the future and thus provide the best trained mineral engineering manpower that is so essential to cope with the increasing problems of mineral production.

(5) Each of the existing mineral engineering departments of the universities are in areas that differ in environment to varying degrees. Thus, each will probably develop its own competency in specialties that will satisfy regional conditions. Cooperative programs can disseminate these specialty techniques. Through interchange, the Nation will be provided with highly competent manpower capable of efficiently producing the vitally needed minerals that occur under various conditions.

(6) Alaska is an excellent example. The State has a population of about 310,000, is approximately one-fifth the size of the United States, has a coastline of more than 26,000 miles compared to 8,683 miles of the coterminous United States, has offshore areas that approach its land area in size, has large mineral occurrences as shown in State and Federal mineral agency publications, possesses an arctic, sub-arctic and temperate environment with accompanying extreme weather conditions, and 80 percent of the State is underlain by permafrost—all of which give rise to many unusual problems. In addition, the university mineral engineering department and its mineral industry research laboratory suffer from low enrollments and limited funding characteristic of other similar programs in the United States.

If more adequate finances would have been available in the past, major emphasis could have been placed on research peculiar to Alaskan problems, such as operation in extreme and varying environmental conditions of temperature, snow, wind, sea ice, seasonal frost, and permafrost.

Such conditions increase the challenges for the mining industry in producing minerals with full consideration to ecology control, pollution and rehabilitation of mining areas in the Northland. Likewise, the challenge remains to use the abundant cold as an asset rather than a liability. The major importance of these factors to mineral resource development to the State and Nation is extremely well illustrated by the Prudhoe Bay-Valdez, Alaska pipeline controversy that is now in the Nation's spotlight.

(7) The acute mineral situation into which the Nation seems to be gradually descending because of a decreasing number of highly skilled mineral-oriented engineers requires the immediate attention of the Nation's congressmen and leaders. Also, it appears evident that the Government department most appropriate to administer the proposed objectives of Senate bill 635 is the one most informed on the Nation's mineral resources and requirements, which is the Department of the Interior.

By way of summary, key facts are:

(a) Agriculture and mining are basic to the Nation's strength and its society.

(b) Agriculture teaching, research, and extension have had the benefit of the various land-grant acts and accordingly have more than met the needs of the people.

(c) Generally, the mining industry has not had such programs, and hence professional mineral manpower is decreasing at a time when greater production is needed.

(d) Senate bill 635 tends to parallel the objectives of the various land-grant acts and would do for the Nation what the land-grant agricultural program has done for the United States.

Consequently, I am in full support of this bill as well as others that may be introduced into the Congress that have the same general purposes. I urge passage and implementation as quickly as possible.

The authors and sponsors of this bill are to be complimented for the excellent bill and its forward-looking planning for mineral supplies for the people of the Nation. Thank you, sir.

Senator Moss. Thank you, Dr. Beistline. As you point out, Alaska might have not been in quite such a difficult problem right now if there had been research done in advance on the proposed pipeline

drops in your State. I have been to your great and beautiful State and certainly you ought to have one of the leading research centers up there in the mining field, I think, of any of the States in the Union. You have so much to be looked at yet. Thank you. We will go on to Dr. Pask now from Berkeley. Dr. Pask.

STATEMENT OF DR. JOSEPH A. PASK, ASSISTANT DEAN, COLLEGE OF ENGINEERING, UNIVERSITY OF CALIFORNIA AT BERKELEY

Dr. PASK. Thank you, Senator Moss. My name is Joseph Pask and I am from the University of California at Berkeley with interest in ceramic engineering and mineral engineering. I am happy to have this opportunity to speak in favor of bill S. 635 as a member of the mineral resources committee, and I heartily support the remarks Dr. Bates has made.

As we know, the basic needs of man and society are food, energy, and minerals. Food production is the only one of these factors properly supported by the Government. Normal economic competition has thus far provided society with its mineral and energy needs. Minerals and energy are important to the maintenance of our material needs and national security; the wealth and strength of nations depends to a great extent on mineral resources within their borders.

Abundant natural resources placed this country in a favorable position. With the depletion of high-grade ores, the low-grade raw materials have not been as economically attractive in comparison with foreign mineral resources. The country has become more and more dependent on nondomestic mineral supplies.

Foreign mineral resources, however, are becoming more difficult to obtain because of the continually changing international scene brought on by worldwide competition and by political changes. The changing political situation, both externally and internally, is such that we again have to become self-dependent relative to mineral needs.

This need requires work on the problem of mining, beneficiation, and processing of low-grade ores but in a new framework and with a new set of ground rules in reference to environmental, ecological, and pollution programs.

Mining and processing must now be done with full consideration of ecological and environmental problems and with a minimum amount of pollution—these problems were not as critical when the population was small and there were wide open spaces and energy was in abundance.

Processing must now also be done with a minimum amount of energy consumption and new sources of energy—these problems were not as critical when unlimited reserves of fossil fuels were still available and pollution was not a problem.

This situation requires more research activity and more trained people to do the research, but even more important we need new ideas, we need creativity, not just a continuation of the status quo. But, unfortunately, the supply of specially trained engineers and research engineers on a nationwide basis is decreasing, and there is even concern about our capabilities of training replacements to maintain a status quo.

This is a reflection of the decreasing enrollments of students in mineral fields in many schools. The tragic consequence of this develop-

ment is that mineral departments and their staffs are being reduced and discontinued at many universities, which is a natural consequence of an educational financing system that is based on maintaining certain student-faculty ratios.

This becomes even more critical in times of decreasing budgets which most of the universities are now experiencing. This situation exists at a time when we need extensive research programs preferably undertaken through graduate students that are supported by strong undergraduate programs since this mechanism fulfills the objectives of the institutes.

Until 1943, at the University of California, Berkeley, there was a college of mines, but at that time it was incorporated into the College of Engineering as the Department of Mineral Technology. Today we teach much of the same disciplines, except for mining engineering in the narrow sense, but several of these disciplines are disseminated within other departments of the college.

Petroleum engineering is an option within mechanical engineering. Geological engineering, which has strong input on mine pit design, underground openings, et cetera, is now part of the Department of Civil Engineering. The activities in extractive metallurgy, mineral processing, ceramic engineering, physical metallurgy, and applied geophysics remain as the Department of Materials Science and Engineering.

The undergraduate enrollments in all of these disciplines have essentially dwindled to mere handfuls, but the graduate programs do remain active. At University of California, Berkeley, graduate research in the properties of materials has been quite well financed, as it has been elsewhere, but financing graduate research in fields concerned with the development of sources and production of raw materials has always had difficulty in obtaining adequate funding.

Government agencies that support research on materials have not historically been concerned with the primary production of that material and have not adequately funded mining, beneficiation, and processing research. If a mineral research institute were established at University of California, Berkeley, it and the department would provide the nucleus for welding these diverse mineral fields together by being engaged in problems of mutual interest in a cooperative way.

The establishment of centers or institutes at land-grant universities, which traditionally have responded to the problems of the State and Nation, will provide the mechanism and climate for stimulating research and generating new ideas.

These institutes would support a continuing staff that would provide a reservoir of knowledge that would not be periodically lost, or perhaps lost forever, and that would continue to have a chance to expand, even though there may be fluctuations in enrollment. The institutes will become stable nuclei for this field of knowledge and, as we know, growth cannot occur without a stable nucleus.

Such institute activity should lead to the creation of ideas for the development of new methods for treating existing low-grade ores or for recycling of scrap materials. The institute will also provide means of training people by supporting graduate students, and this is perhaps the main argument for having such institutes associated with universities.

For example, California is a principal source of minerals, but there are substantial resources that are presently not workable, and the Nation would benefit from any progress in the development of methods for utilizing them.

For example, large deposits of complex sulfides, predominantly pyrites rich in copper, zinc and silver, occur in the Lake Shasta region. Satisfactory processes have not yet been developed for their use. As an aside, all processes dealing with the treatment of sulfide ores require study because of the possibility of SO_2 pollution from the smelters.

A huge potential source for metals are the extensive deposits of California serpentines which run as high as \$50 per ton in metal content (0.1 to 0.2 percent copper and 0.1 to 0.2 percent nickel, et cetera). These might become ores after the silicate chemistry of extraction and methods for mining have been worked out. They are abundant and, interestingly, do not support houses, trees, et cetera.

Also, California is a large producer of industrial minerals and clays and further research may extend the utilization of this kind of important resource. With California's large coast line, the mineral resources of the sea and the sea floor are potentially very important.

Research in mining and processing will be necessary to utilize such materials as the phosphorites and manganese nodules. In addition to its petroleum reserves, bituminous sand in shallow oil fields which also carry significant amounts of uranium and vanadium may provide a source of energy.

Other low grades that might have potential, provided economic mining and processing methods can be developed, include such low-grade ores as chromite, tungsten, gold, and nickel laterites. In the State of California, with vast numbers of people, recycling waste materials offers a significant resource for metals and other materials. This is an area that is just beginning to open up as a technology. The mineral research institute would provide the necessary mechanism for conducting a strong research program in this area.

The institutes will provide forums for discussion. This should lead to stimulation and interchange of ideas between groups. They will also serve as a focal point for promoting cooperation between industry, universities, and Government agencies, in this case primarily the U.S. Bureau of Mines.

This overall approach should provide a considerable improvement in our capabilities for the discovery, development, and intelligent use of our mineral and energy resources; for the development of new products and new industries; and for the development of a reservoir of knowledge related to this field which in itself becomes a natural resource that is necessary and critical for the continued welfare of our Nation.

Senator Moss. Thank you, Dr. Pask, for that statement pointing out the needs as you see them. I am sure that the fact that your school was dispersed among the other disciplines is indicative of the kind of downgrading that came to our schools of research in mining and metallurgy.

Perhaps we can reverse the trend with this legislation. We hope we can. Dr. Planje of the University of Missouri. Dr. Planje, we would be glad to hear from you, sir.

**STATEMENT OF DR. THEODORE J. PLANJE, DEAN, SCHOOL OF MINES
AND METALLURGY, UNIVERSITY OF MISSOURI AT ROLLA**

Dr. PLANJE. Thank you. I am a ceramic engineer by profession. I serve as dean of the University of Missouri, Rolla, which was formerly the School of Mines and Metallurgy established in 1971. I sincerely appreciate the opportunity to present the concerns and views on the legislation under consideration which are in essential agreement with those of the administration of the University of Missouri, a four-campus, State land-grant institution.

As the engineering campus of the university, the Rolla campus, which was established in 1870 through the State's participation in the provisions of the Morrill Act of 1862, is commemorating its centennial year of service to mineral engineering education and the mineral industries of the State, Nation, and the some 60 foreign countries in which its alumni are employed.

The mineral engineering faculty of the University has requested that I prevail upon you gentlemen to report their collective concern for the many problems confronting this Nation in meeting the demands for mineral resources in the years ahead, and in evolving in these years a total resource management program for essentially complete recovery and recycling of metals and minerals to insure their retention for use in the centuries to come.

Of immediate concern are the numerous projections which have been made in the recent past for the growth in demand of primary mineral resources in the decades ahead to the turn of the century, the more conservative of which suggest that it will double, the more optimistic that it will quadruple.

In light of the many problems confronting the mineral industries in the areas of health and safety, air and water pollution, reclamation, mounting operating costs, competition for domestic resources in foreign markets, and the lack of any significant improvement in mineral technology in the past two decades, either projection should be cause for significant concern on the part of the industry, Federal and State agencies, and particularly the general public, which will be the ultimate beneficiaries of the success or failure of the first two bodies in attaining the levels of productivity required to sustain economic growth and security of the Nation and preservation of its environment.

The degree of success in fulfilling our mineral resource need in the decades ahead will be largely dependent upon our ability to assess on an adequate time base the future demands for the major and most critical mineral commodities and to develop a plan for fulfilling the demands for each in a manner which will yield some reasonable first order, if not ideal and final, solutions to the many problems which confront the mineral industry at this point in time.

If I may depart from the written text, I would like to make a brief comment on mineral consumption. This is a matter, I think, of concern to this generation but more particularly to many of those here today. If we take, for example, in this country the past year we consumed some 150 million tons of iron and steel products.

This means that each man, woman, and child participated in consumption of some three-quarter tons of iron and steel products. If each

man, woman, and child in the world today were to continue consumption at the same rate, our known world reserves of iron ore, as evident from the Mineral Yearbook of the U.S. Bureau of Mines, would be depleted in 8½ years.

That assumes, of course, that we depend solely on primary metal. I am sure we would all hope this plan might sustain people for many more years than 9 in terms of their need for steel products. I feel this is the critical item to which this legislation addresses itself, because we are starting a national awareness of how do we manage in total our mineral resources, and I would be most hopeful that the National Industrial Mineral Commission and the proposed National Commission on Fuels and Energy would update and extend their studies for the many generations to come. Others have already spoken to this matter of our national production.

Hopefully the recently established National Industrial Materials Commission and the proposed National Commission on Fuels and Energy will pursue their charges with some haste to update and extend the studies of the earlier Materials Policy Commission.

Because of the interdependence of supply of energy from fossil fuel and nuclear sources, the Commission on Fuels and Energy will probably find it difficult to report any of its findings much in advance of completion of the total study.

However, it would be most helpful if the Industrial Materials Commission could pursue its assessment of the supply and demand for individual mineral and metal commodities on some priority basis and make available preliminary reports to provide a basis for the development of a mechanism for planning, which hopefully will evolve as a cooperative effort between the concerned agencies of Government, industry, and education, to identify and seek solutions to the economic, technological, political, and social problems anticipated in the course of fulfilling the projected demand.

A secondary benefit of such a cooperative effort would be the establishment of better communications and coordination between the groups directly involved than have prevailed in the past. These groups must, in turn, seek to influence the deliberations and decisions of the several agencies concerned with the Nation's technological activity and its impact upon our participation in world trade, since it is most apparent from news releases in the past month that only the short-term consequences of our mineral supply and technologies have been considered in assessing our world trade position. Our future dependence upon mineral import cannot be neglected in our economic planning or in international relations.

There is general recognition and agreement that our present mineral technologies are critically inadequate. New technologies must be forthcoming for exploration, recovery, and beneficiation, as well as extraction and other processing of ores and minerals, in the interest of health and safety in the industry, as well as the economics of the industry, concurrent with a significant reduction in industry's consequences upon the environment and the energy demands of many of its processes.

New technologies have been proposed and additional ones are being suggested with increasing frequency. Most of these remain to be assessed for economic and operational feasibility and subsequent reduction to practice. Such studies have been and will be delayed by

the shortage of personnel with training in the fields of mineral engineering and science and the available funding.

Since the orbiting of sputnik, undergraduate and graduate enrollments in the mineral engineering disciplines of ceramic, geological, metallurgical (mineral dressing and extractive metallurgy), mining and petroleum engineering have declined as a consequence of the publicity and Federal funding committed to fulfilling the manpower and the research and development needs of the space and other programs.

The subsequent decline in the mineral engineering enrollments led to increases in instructional costs, and some accredited programs were discontinued. Others have been merged with larger, non-mineral-oriented programs solely to provide continuity of employment for tenured faculty.

Only ceramic and metallurgical engineering shared in the increase in engineering enrollments during this period. However, the majority of the students in these two disciplines selected the materials-oriented specializations, which specializations received grant support from NASA, DOD, and NSF.

During this period the enrollments in the mineral and metals processing specializations of these two disciplines decreased with a corresponding decline in faculties and facilities in these fields. The current state of our mineral technology is attributable to the decline in the education of mineral engineers in all disciplines and the attending decline in academic research and development. Another contributing factor was the concurrent increase in mineral consumption of the several national programs during this period.

Until such time as the final reports of the National Industrial Minerals Commission and the National Commission on Fuels and Energy become available, projections of mineral engineering personnel needs in the decades ahead cannot be made with confidence.

However, based on the recent estimates for growth in mineral consumption, the number of mineral engineers must be increased significantly. It has been suggested that in the future the number must increase in direct proportion to the increase in mineral demands, since new technologies for exploration, mining, and subsequent processing of minerals with adequate control of all liquid and gaseous effluents of the processes for environmental control will require fewer semiskilled and skilled personnel and greater numbers of engineers.

This, of course, follows the trends in other industries which have mechanized operations, adopted more technically sophisticated processes, and pursued the problems of process control in the interest of efficiency and the environment. With increasing demands and declining quality of our reserves, the increase in efficiency of mineral recovery in all processes will be essential.

It is the sincere conviction of the faculty of the University of Missouri-Rolla that the ongoing academic programs in mineral engineering have the faculties and the basic facilities to increase the annual productivity of graduates by a factor of at least four, and in fact the present undergraduate and graduate enrollment should be doubled, if these programs are to survive as mounting restrictions on university budgets require the elimination of high instructional cost programs.

With few exceptions, the faculties of the ongoing mineral engineering programs have the competence and capacity to expand signifi-

cantly their academic research and development activities. Over the past two decades these activities have been limited by the availability of funds within the university budget for the support of graduate education, as augmented by grants and gifts from industry and industrial foundations.

The latter must be given a large measure of credit for the very survival of mineral engineering education in this country. Until it has been demonstrated that the present accredited academic programs lack the capacity to fulfill the demands for mineral engineers in both industry and Government, the establishment of new programs should be deferred to avoid the current problems resulting from the over-supply of aeronautical and aerospace engineers and scientists.

Gentlemen, in summary, as a representative of one of the some 100 member institutions of the National Association of State Universities & Land-Grant Colleges, I fully support the excellent and timely provisions of S. 635 for the following reasons:

1. The land-grant institutions through their educational programs and academic research and development activities have and will continue to make significant contributions to the development of new technologies for agriculture, education, health services, and industry, and through their extension services have participated effectively in reducing such developments to practice.

2. The mineral engineering programs of the land-grant institutions have rendered some 100 years of service to industry and Government, and their faculties have the dedication, concern, and capacity to contribute effectively to the fulfillment of the objectives of this legislation.

3. The legislation will serve to evidence to the general public a national concern for the critical mineral resources problems of short- and long-term consequences and the opportunities for the young people of this country for challenging and rewarding careers in the several fields of mineral engineering.

4. While the proposed level of annual funding for the institutes to be established through this legislation is modest by comparison with that afforded other (academic research and development) programs, it is deemed most adequate to revitalize the academic research and development activities of the mineral engineering programs which have all too long been limited to support from general institutional funds and contributions from industry.

5. The revitalization of academic research and development activities through the establishment of the proposed institutes within the ongoing mineral engineering programs of the land-grant institutions will attract increasing numbers of students to prepare for careers in these professions, such that an important byproduct of this legislation will be its contribution to the future manpower needs of industry, Government, and education in these professions.

6. The administration of this act by the Secretary of Interior will provide an opportunity for closer communications between the Secretary, his staff, and the academic community, a channel parallel to that which has so well served agriculture needs of this country through the years.

I would like to thank you, Senator, on behalf of my faculty and my colleagues in the community for extending this opportunity to participate in the hearings, to commend you and your colleagues for your

foresight as evidenced in S. 635 and to wish you success in implementing this legislation. Thank you, sir.

Senator Moss. Well, thank you very much, Dr. Planje. That was an excellent statement. We appreciate your highlighting it for us and your general accord with the opinions of your colleagues who are appearing here. I think the fact that all five of you are here representing the land-grant colleges speaks loudly for the needs that you feel.

You certainly are from varied parts of the United States with different problems locally but basically you have the same recommendation here on this legislation. We will hear from Dr. Ludlum before we recess for lunch. Senator Randolph had wanted to be here to introduce Dr. Ludlum. He is very proud of the dean of the Graduate School of the University of West Virginia. I have Senator Randolph's statement and I will have it put in the record just prior to your testimony, Dr. Ludlum. He recommends you very highly.

(The document follows:)

STATEMENT OF HON. JENNINGS RANDOLPH, A U.S. SENATOR FROM THE STATE OF WEST VIRGINIA

Mr. Chairman, I am appreciative that you have scheduled a distinguished West Virginian to be heard this morning as a witness to testify on S. 635.

Dr. John C. Ludlum has a well deserved reputation as a leading educator and administrator. He brings to this hearing not only his personal competence but experience gained at the state university of the leading coal producing state in our country.

Please know that I, too, support the aims of the legislation now being considered by the Subcommittee.

For a number of years there has been a growing awareness that more activity is needed in the mineral industries to improve working conditions as well as the efficiency with which these earthly resources are extracted.

This legislation, S. 635, is directed at the total mineral industry of the United States. I will concentrate my observations on coal for this is the principal industry of my state and the one with whose problems I am most familiar.

In the past three years a series of events has brought coal and coal mining to wide public attention. Serious fuel shortages in the United States have emphasized the urgency with which production must be increased. At the same time there has developed a new awareness of the very real hazards faced by the men who mine coal underground. This area of concern was brought most forcefully and tragically to public attention by the disaster at Farmington, West Virginia, in November, 1968, in which 78 miners died.

During this same period we have witnessed the environmental concern and the efforts to effectuate general environmental improvement.

All of these factors are interrelated. They mean that the production and utilization of coal must be viewed in new terms. They mean that new questions are being asked for which we do not have answers. The bill being considered by this Subcommittee is designed to help us find these answers. It would help to meet the deficiencies of inadequate research and the shortage of trained technicians.

I do not believe the programs this bill proposes would be in conflict with existing activities. Rather, it would supplement existing programs, such as those authorized by the Coal Mine Health and Safety Act of 1969 and the Appalachian Regional Development Act Amendments of 1969.

Both of these Acts, and others, have had a significant impact on West Virginia. I am sure that S. 635 would be similarly valuable to my state.

I cannot emphasize too strongly the need for accelerated research related to coal mines. We must devise new ways to recover coal from the ground with greater efficiency and safety. At the same time, coal must be mined in ways that do not cause undue damage to the environment or inflict disease and injury on miners.

At the present time the coal mining states of Appalachia are grappling with severe problems caused by 5,700 miles of streams polluted by acid mine drainage.

In West Virginia the control of strip mining is one of the most controversial public issues. The environmental challenges presented by strip mining are evident

in my state, where strip mining grew in 1970 while the amount of coal produced by deep mines declined. This means that techniques for the reclamation of mined lands are more urgently needed than ever before.

The fact that the number of mine deaths in 1970 was higher than in 1967 shows that much work remains to be done in this field.

As I said earlier, S. 635 is nationwide in scope, covering as it does all minerals produced in this country. With respect to coal, I believe it would be especially applicable to West Virginia. I further believe that our institutions of higher learning, including the School of Mines at West Virginia University, are well situated to implement its provisions.

I commend the objectives of this legislation.

STATEMENT OF DR. JOHN C. LUDLUM, DEAN, THE GRADUATE SCHOOL, UNIVERSITY OF WEST VIRGINIA, MORGANTOWN

Dr. LUDLUM. I appreciate that very much, Senator Moss. In the interest of time I will cut my already short statement about in half. In addition to being dean of the Graduate School of West Virginia University, perhaps more pertinent to the subject at hand is my 25 years of experience as professor of geology there.

I have studied Senate bill 635 and consider its enactment and implementation a most urgently needed step in upgrading research technology and training in resource fields vital to our economy and national strength. The president of West Virginia University and the dean of our school of mines have considered the sections of this bill with me and concur in this support. So do industrial leaders of the mineral industries in West Virginia where the annual value of mineral production is now on the order of \$1 billion; \$1 billion a year are also added to West Virginia's economy in production, transportation, and manufacturing connected with the industry, and in wages, services, and purchase of equipment and supplies.

West Virginia is central to an Appalachian region comprised of other important mineral-producing States including Pennsylvania, Illinois, Ohio, Kentucky, and Virginia which together have annual mineral production of between \$4 and \$5 billion in value. All have many problems, some unique, that the enactment and implementation of this bill can go a long way toward correcting.

The provisions of S. 635 wisely provide sufficient flexibility to accommodate the peculiar needs of each State and region and yet include the necessary controls to insure focus on only mineral-related problems. The strong base of mineral production in our State and region is coal, and we have the problems associated with coal mining.

In States where metallic mineral production is most important, problems of developing the technology to discover and produce low-grade deposits profitably are important because the finds of high-grade ore are now very few. In States of high population and economy based on manufacturing, land use in the production of construction materials and disposal of waste products at the surface and underground will be some of the problems that can be given the corrective attention they need under this bill.

Thirteen out of thirty U.S. schools or departments accredited for teaching mining engineers in 1947 have since been discontinued. Fortunately, our school has the stature gained over almost 60 years, and will not only be continued, but be strengthened to meet its increasing responsibilities. But our State has a small population and our State government is too hard pressed to be able fully to finance the

progress needed. Schools that have continued to provide quality programs in the face of adverse international trends now merit the support of this Federal partnership.

As Mr. Haynes has already testified, the coal industry alone can absorb our present nationwide output of mining engineers for the next 5 years. I understand that the Soviet Union graduates each year over 10 times the number that we do, and in general is working with mineral deposits of higher grade. Our search for new staff finds the pool of those qualified and available very, very small indeed in the face of increasing demands upon us for research and training in areas of new emphasis.

Today per capita demand for minerals in the United States amounts to about \$150 per person per year and projections indicate almost a tripling to \$420 by the year 2000. Our present production deficit is about 22 percent of production requirements and projections indicate a production deficit of 50 percent by the year 2000.

As mines in other countries are nationalized, it is obvious that filling the deficit from imports will be increasingly more difficult and certainly more expensive. We had better plan, train, and develop the technology necessary for the best sufficiency possible in mineral resources for the future, or stand to expect serious disruptions to our economy and living standards. Senate bill 635 is a logical approach incorporating much of the best in proven models for such a national effort in preparedness. I support it fully.

Mr. Chairman, with respect to the testimony of a previous panelist, Mr. Herbert Richey, I don't think we should underestimate the level of training of Soviet mineral engineers. I have information from the Soviet Union specialists of the U.S. Department of Interior as follows:

Undergraduate and graduate studies in the Soviet Union are offered in universities and technical institutes. All technical training is characterized by a high degree of specialization. The 5-year Soviet engineering student of geology, mining, petroleum, or metallurgy may specialize in any one of 35 fields of applied study.

In the engineers' institute, which includes all the engineering professions, required class attendance is high throughout the 5-year program. Another is the evening and correspondence school courses. The statistics are listed below as to the total number of graduates in mineral and metallurgical studies in the U.S.S.R. in 1969 as follows:

In the field of mineral geology, geophysics and exploration, 4,500. In mining and petroleum, 4,800. In metallurgy, 5,900 for a total of 15,200. Compared to our production of graduate mining engineers, I think the last figure I had was 114 per year.

Thank you very much, Mr. Chairman.

Senator Moss. Thank you very much, Dr. Ludlum, for that fine statement. I am glad you had some additional figures on the number of trained personnel coming from the Soviet institutes, regardless of what level they are. The number is so overwhelming that we can readily conclude that they are putting much greater emphasis on developing their mineral resources than are we. It gives us a measuring stick of what we aren't doing and what they are doing and allowing us to make a judgment whether we are being prudent in this country in developing our mineral resources.

All of you gentlemen have concurred in your approval of the legislation before us and certainly you have given us some very valid reasons for proceeding along that line.

Dr. BEISTLINE. I would like to introduce for the record a statement of the Alaska Miners Association which is in support of Senate 635. I would not read the statement, but emphasize merely two or three sentences in this.

Senator Moss. Very good.

Dr. BEISTLINE. The Alaska Miners Association has between 500 and 600 members distributed throughout Alaska. Certainly Senate 635 supports the aims of the Mining and Mineral Policy Act of 1970. It would stimulate mining education and hence the mineral industries in the whole country, but as an association we want only to comment on the beneficial effects to Alaska, realizing full well the administration of our State and the country are interdependent.

We must reestablish a mineral industry or suffer severe detrimental economic and social effects to both State and Nation. We are working toward this end in every way possible: by encouraging favorable legislation, investment in exploration, public works, education of the public, and support of mineral education at our university. We welcome the opportunity to support this bill.

From there on the statement goes into possible types of research that the association feels necessary in Alaska. Thank you, sir.

Senator Moss. Thank you, we are very pleased to have that as part of our record and it will appear in full.

(The document follows.)

STATEMENT OF ERNEST N. WOLFF, PRESIDENT, ALASKA
MINERS ASSOCIATION

The Alaska Miners Association has between 500 and 600 members distributed throughout Alaska. Last fall, at our annual Directors' meeting, we adopted unanimously a resolution supporting H.R. 19492, a bill similar to the one now under consideration. Certainly, S. 635 supports the aims of the Mining and Mineral Policy Act of 1970. It would stimulate mining education and hence the mineral industry in the whole country, but as an Association we want only to comment on the beneficial effects to Alaska, realizing full well that the welfare of our State and our Nation are mutually interdependent.

Alaska is unique among the States because of its northern location and its separation from the other States with their centers of population. Because of these conditions, much of Alaska is unable to produce surface products to provide and economic base. Mineral production, therefore, becomes proportionally more important in Alaska. We as an Association know that Alaska must reestablish a mineral industry or suffer severe detrimental economic and social effects to both State and Nation. We are working toward this end in every way possible: by encouraging favorable legislation, investment in exploration, public works, education of the public, and support of mineral education at our University. We welcome the opportunity to support this Bill.

We would like to suggest some general lines of research that could be conducted in conjunction with mineral education at the Institute that would be established at the University of Alaska:

GOLD

Placer gold mining was for a long time the mainstay of Alaskan industry. Recently, studies by the U.S. Bureau of Mines, U.S. Geological Survey, and the University of Alaska have indicated that significant quantities of very fine gold may be present in placer gravels. This gold is lost during placer mining. Further research aimed at evaluating and recovering such gold could help to reestablish our gold industry. In view of the growing concern for the environment, before we could have a general revival of placer mining, means of controlling the discharge of silt should be developed. For placer exploration the churn drill has been the traditional tool. It is absolutely necessary to adopt a faster drill for this work. Rapid portable means of detecting sub microscopic gold should also be developed.

GUIDES TO ORE

The study of regional guides to ore deposition has been started by several agencies including the University of Alaska. These studies should be expanded and intensified.

Most of our mining districts have not been studied, or were described only on a reconnaissance basis years ago. Local guides to exploration in each district need to be worked out, and this could be done through student theses.

The development of the computer has made it possible to handle large amounts of data. Statistical guides to Alaskan ores should be developed as well as computerized methods of plotting data on maps.

COAL

Our coal reserves have been estimated at well over 100 billion tons. This tremendous resource represents a great source of wealth to the State and the Nation. Intensive research is needed to adopt this coal to new uses, and to develop methods of upgrading it so that it can be exported.

OFF-SHORE

Alaska has a very long coast line and extensive continental shelf. Our tremendous off-shore mineral potential should be investigated.

DISSEMINATED DEPOSITS

The trend in the western United States and Canada is toward the discovery and development of large disseminated deposits rather than veins. The response of these bodies to geochemical prospecting in a sub-arctic environment needs intensive study.

ECONOMICS

Detailed, factual economic data concerning mining in an undeveloped area need to be developed, as well as economic feasibility studies.

Such research as suggested above, as well as much more, would enhance the chances of establishing a mineral industry in Alaska. It is of a type that can well be undertaken in conjunction with teaching. Again, the Alaska Miners Association urges the adoption of S. 635.

Senator Moss. I thank all of you gentlemen who have appeared this morning. We are going to recess now until 2 p.m. I pointed out in the beginning that we had a long list of witnesses to hear and there are still a number on the list. If there are any who find it is inconvenient or difficult for them to return and they want to submit their statements to the clerk here before they leave, we can incorporate them in the record, but otherwise be back here at 2 p.m. and we will continue what I think is a very fine hearing. I haven't heard a discordant note yet.

We stand recessed.

(Whereupon, at 12:30 p.m., the luncheon recess was taken.)

AFTERNOON SESSION

Senator Moss. This hearing will resume.

We have a panel composed of Dr. McBride, Dr. Kent, and Dr. Lutz who will come to the table now, if you will, please, gentlemen. Dr. McBride is president of the Colorado School of Mines, Dr. Kent is dean of the College of Engineering of the Michigan Technological University, and Dr. Lutz dean of engineering in South Dakota School of Mines and Technology.

This is a very illustrious panel. We have had most distinguished and knowledgeable witnesses today and we are glad to continue with you gentlemen. As I have indicated, the general order is that your state-

ment that you prepared will be in the record in full in any event and if you care to summarize or highlight it in any way you may do so.

Dr. McBride, would you proceed, sir?

**STATEMENT OF DR. GUY T. McBRIDE, JR., PRESIDENT, COLORADO
SCHOOL OF MINES**

Dr. McBRIDE. Thank you, Senator Moss and Senator Allott. Perhaps you wouldn't mind a bit of levity at this point in the proceedings. I and my colleagues feel a little bit like the goats, Dr. Gates collected all the sheep from land-grant colleges and he left only us goats. So the goats got together and I hope the odor won't be overpowering.

Senator Moss. Well, I expect most goats have a pretty good punch, so go ahead.

Dr. McBRIDE. I would like to state three things very briefly. First of all, all of us, Dr. Lutz on my immediate left and Dr. Kent on my far left, will obviously speak very strongly in favor of S. 635. I wish to join the others to commend those who drafted the bill and those who inspired the bill, particularly our good friend Dr. Osborn.

Those of us who are testifying are under some handicap because the material which we might otherwise present has been so ably presented by the National Academy of Science and Engineering Committee on Mineral Science and Technology and all of us in the room, including the distinguished Senators, have studied those reports and it would really be unduly time consuming for me to quote from them.

I would like to limit my comments on this point by saying that I and my institution and I believe others like it support the recommendations of that report, particularly the report of its panel on planning which worked under the chairmanship of my association, Dr. John Reid of the Colorado School of Mines.

We believe not only the recommendations of that report are very much in order and should be seriously considered, but that the provisions of S. 635 constitute a timely, desirable, and most necessary step toward the fulfillment of some of the major recommendations of that notable report.

And now not because we are unaware of the national problems which have been alluded to by others here but because I thought perhaps a few points about what is happening in the mines might be of interest to the committee and might shed some particular light on the problems that this bill is designed to alleviate, I would like to call your attention very briefly to three things.

First, the demand for our product continues extremely high. Our mining engineers in the class of 1971 have as many job offers as they would encourage. We are going to graduate approximately 25 percent of the 114 to 125 mining engineers in the country this year.

We have been doing this for at least 12 years. We could place easily 10 times that number without any question. So that the demand for mining engineers is extremely high and this is a different picture from the job market for mechanical and aerospace engineers.

The bleakness of their job market has received so much publicity that the general public, including that part from which we recruit students, appears to have formed an unfavorable opinion of engi-

neering as a paying career and obviously has handicapped our recruiting efforts very seriously.

The mention of recruiting brings me to the second point, which is a serious problem for my school and I believe it is or will soon be a problem of comparable magnitude for other publicly supported mining institutions. That is the problem of recruiting able out-of-State students in the face of nonresident tuition figures established by State legislatures, which are unprecedentedly high.

Now, the fact that States are moving in this direction is beyond question. Nor is this the place to talk about the parallel trend calling on all college students to pay the cost of their education as they receive it or obligate themselves to pay for in the long future.

But it is true that schools like mine and I suspect like Michigan and South Dakota, our schools have recruited extremely assiduously in the State. We feel we are attracting to mines substantially all of the students from within the State which can be attracted there.

We have selected admission but not competitive admission. When the out-of-State tuition is raised to extremely high levels, it is bound to have an extremely adverse effect on our recruiting. For example, the nonresident tuition at "Mines" has just been mandated by the General Assembly of Colorado to be \$1,691 per year, an increase of \$1,100 from last year.

For the last 10 years "Mines" has been growing at the rate of 3.8 percent per year for enrollment. Our enrollment this year was 1,720. We are predicting and budgeting for an enrollment of only 1,760 in 1971-72 because we are apprehensive of the effect of the extremely high out-of-State tuition.

It would be my very strong hope that the provisions of section 4, the block grant section of Senator Allott's bill, could be interpreted to permit us to use some of this money for partial out-of-State tuition scholarships. I believe this is only a proper recognition of the fact that the schools which we represent are in fact a national institution rather than a State institution and that it is probably not to be expected that a single State bear the load to educate a large fraction of the mining engineers in the country and in the world.

The third point which is perhaps even more fundamental is that to paraphrase a famous saying, we have met the enemy of improved mining engineering education and research and the enemy is formula budgeting. Mining engineering departments in institutions are relatively small in number even though they are extremely important on the impact on the national welfare.

Consequently we have only a small voice in the allocation of funds and we have the meager amounts to call for by the dollars per student credit-hour and faculty per student credit-hour approach. These funds do not provide the flexibility that is required at this stage in the existence of our mining schools.

It is my feeling that the section 4 block grant and section 5 project appropriations of S. 635 will provide this flexibility and margin for excellence. The block grants will upgrade and enlarge our basic manpower production at the baccalaureate level and the project funds to permit and encourage, but only as we deserve them, our program of research and education.

Gentlemen, I appreciate your patience, I admire your patience and I certainly am pleased to be able to speak in support of the bill before the rather distinguished Senator from Colorado.

Senator Moss. Thank you, Dr. McBride, we are pleased and honored that you would come and appear before us. We are aware, of course, of the towering stature of Colorado Mines in this field of mining engineering and metallurgy. I was interested to learn that you turn out 25 percent of the graduates of this country. It is astonishing that so many come from one institution, and consistently do so year after year. The record speaks well for the great school that you head. No one could speak to us with more authority on the needs of research and education in this field than you, so to have you testify for us has been a real pleasure. We are glad to have you and your other distinguished colleagues who are occupying this goats' panel as you have called it.

I appreciate what you have to say. I think Senator Allott has a word or two or a question.

Senator ALLOTT. Just one very short matter. I am of course happy to have Dr. McBride representing our great School of Mines as the president of it. We have always been very proud of it. But you raised one question, Doctor, which I would like to explore with you just a moment. You talked about the raising of the nonresident tuitions. Actually would you not say that there is a difference between the School of Mines in this respect and the other State institutions of higher learning? In other words, the pressure for the admittance of out-of-State students at Northern Colorado University, Colorado State University, the University of Colorado, even places like Adams State which is somewhat remote geographically, is extremely great and they have just had to put some arbitrary limitations on that, as you know.

Isn't the situation a little bit different as far as justification for the situation goes?

Dr. McBRIDE. I think it is very much different, Senator Allott, and I believe my colleagues here will echo what I have to say. We absolutely must have the out-of-State students in order to fill the manpower needs of the minerals industry. Furthermore, it has been my observation that our students tend to come from homes of moderate income. So this high tuition, and I am using the word, I realize, perhaps with more precision than I should have, relatively high out-of-State tuition puts a barrier between these middle-class—financially speaking students and education which they simply cannot get in their home State.

A young man from middle Kansas, where can he go to study mining engineering if not to the Colorado School of Mines? It is the logical place. The other schools, I believe, have many more out-of-State output at high tuition levels than they can possibly accept and the people at Colorado University have stated publicly that they don't care how high the out-of-State tuition is raised because they will always have more out-of-State students than they can take.

Senator ALLOTT. Do you have any figures with you on the out-of-State tuitions at, say, Colorado State University and the University of Colorado?

Dr. McBRIDE. Yes; the out-of-State tuition at those universities for the school year 1971-72 which is fiscal 1972 has been mandated by the legislature at exactly the same level. CU is \$1,691 and CSU, I believe the figure is \$1,642.

Senator ALLOTT. Now, since the essential nature of the Colorado School of Mines has always been a little different from the traditional university in that it is almost in one respect a postgraduate school, although I know you have postgraduates, but maybe I am just indulging in some States matters here, but was tuition set at the same rate for the Colorado Medical School and the law schools—the professional schools?

Dr. McBRIDE. I can't speak for the law school, I don't recall those figures. The medical school figures are substantially the same as the ones I just quoted you.

Senator ALLOTT. All right, thank you very much, Doctor, I appreciate your statement.

Dr. McBRIDE. My pleasure, sir.

(Dr. McBride's prepared statement follows:)

STATEMENT OF DR. GUY T. McBRIDE, JR. PRESIDENT, COLORADO SCHOOL OF MINES

Mr. Chairman and Members of the Subcommittee:

I and my colleagues, Dr. James A. Kent, Dean of the College of Engineering, Michigan Technological University, and Dr. Carl Lutz, Dean of Engineering, South Dakota School of Mines and Technology, are honored to be heard by the Subcommittee on behalf of our institutions both separately and as members of a class of non-land grant mining engineering schools. Others of this group, of which our institutions are representative, are the Montana College of Mineral Science and Technology and the New Mexico Institute of Mining and Technology. Each of the three of us will speak briefly, but very strongly, in favor of the pending bill S. 635, for it promises desperately needed help, both short- and long-range, to alleviate the present critically unsatisfactory state of mining engineering education and research.

The first practice of mining may have been the securing of salt produced by the natural evaporation of saline spring water, or perhaps it occurred the day primitive man rolled a stone from creek bed to cave to sit on, for mining is, by definition, the deliberate winning from earth or sea of a natural substance for the use of man. Most persons think of mining in terms of the underground working of seams of metallic minerals or coal, and these are important, but as has been stated here today, vast tonnages of industrial minerals are won not only by the open pit mining of sand, gravel, and stone and of coal, phosphate rock, and metallic ores but by well mining of oil, gas, salt, and sulphur. Mining engineers and mining engineering techniques are employed in civil engineering works involving the excavation of enormous volumes of earth and rock and the use of the rock remaining in place as a structural material.

Informed persons in government, in education and educational foundations, and in industry have become increasingly concerned at the imminent threat, and indeed, actual damage, to this major American and world industry from what they, and I, discern to be a grievous failure to advance its fundamental technology and to provide the trained manpower to lead it. These failures are alike centered in our schools of mining engineering, for research and teaching are synergistic—whether improving or deteriorating.

This situation, as I suspect all of the members of the Subcommittee and many of the members of the audience are aware, was investigated definitively by the 1966 Committee on Mineral Science and Technology under the joint aegis of the National Academies of Science and of Engineering and the distinguished chairmanship of Dr. E. F. Osborne, now Director of the U.S. Bureau of Mines. The authoritative report of this Committee, members of which will testify before you at this hearing, was published in 1969; the matter of the report of the Panel on Mining is especially germane to this inquiry. As it appears quite certain that this report is familiar to you and will be introduced in statements by others more competent than I, I will not reiterate its provisions but will state unequivocally that I wish to associate myself and my institution with the findings and recommendations contained therein. May I further state that I believe the provisions of S. 635 constitute a timely, desirable, and most necessary step toward eventual fulfillment of the recommendations.

Indeed, the problems of lagging technology and of inadequate manpower, stemming in part from fiscal undernourishment, have become more rather than less serious since 1966-1969. In the thought that the current adverse pressures at the Colorado School of Mines may well be typical of those sought to be alleviated by the provisions of S. 635, may I speak briefly to three points: First, the demand for our product continues high; each 1971 mining engineering graduate has as many job offers as he encourages; and this is a completely different picture from the job market for mechanical and aerospace engineers, the bleakness of which has received so much publicity that the general public, including that part from which we recruit students, appears to have formed an unfavorable opinion of engineering as a paying career.

This mention of recruiting brings me to the second point, which is an emerging, fundamental problem for the Colorado School of Mines. Many publicly-supported mining engineering institutions either now have or will soon experience our problem of recruiting able out-of-state students in the face of nonresident tuition figures established by state legislatures at hitherto unprecedentedly high, deliberately discriminatory levels. The right and responsibility of states to move in this direction is of course unquestioned; nor is this the proper forum to debate the civic wisdom of the parallel trend to charge all students an increasingly large fraction of the perceived cost of their education. But it seems certain that schools, like Mines, which have recruited to the fullest in state, may expect to be seriously hampered in obtaining the students needed to bring mining engineering curricula to a level which is economically viable and which will satisfy the predicted demand for graduate engineers. For example, the nonresident tuition at CSM has just been mandated to be \$1,691 per academic year, increased from \$1,100 in 1970-1971. We are accordingly predicting that our enrollment, which increased at 3.8% per year during the last decade, will *decrease* from 1720 in fall 1970 to 1670 in fall 1971. It is my hope that the provisions of Sec. 4 of S. 635 may be interpreted to permit use of some of the "block grant" money for partial tuition scholarships to nonresident students, as I believe this to be consistent with the concept that the mining schools serve a national, rather than a purely state, need.

Finally, to paraphrase a familiar saying, we have met the enemy of improved and enlarged mining engineering education and research, and it is "formula budgeting". Mining engineering departments and institutions, being, in spite of their very great importance to the national welfare, only small units of the tremendous enterprise of higher education, have a small voice in the allocation of funds and are typically given only the meagre amounts called for by the dollars-per-student-credit-hour and student-credit-hour-per-faculty-member approach coming more and more to be used in establishing state appropriations. These funds simply do not provide the flexibility and the margin for excellence which is now necessary. The Sec. 4 block grant and Sec. 5 project appropriations of S. 635 will provide this flexibility and this margin, the former to upgrade and enlarge our basic manpower production at the baccalaureate level and the latter to permit and encourage, as we deserve them, our programs of graduate research and education.

Gentlemen, I submit that this hearing is a part of the current national debate over the allocation and reallocation of our material and human resources, and I suggest that it is overwhelmingly in the national interest that the resources allocated to mining engineering education and research be increased and that the appropriations called for by S. 635 be effected at the earliest practicable time.

Senator Moss. Thank you, sir, and we will now ask Dr. Kent, dean of the College of Engineering, Michigan Technological University, if he will deliver his paper to us.

STATEMENT OF DR. JAMES A. KENT, DEAN, COLLEGE OF ENGINEERING, MICHIGAN TECHNOLOGICAL UNIVERSITY, HOUGHTON, MICH.

Dr. KENT. Thank you very much, Senator Moss and Senator Allott. In view of the detailed testimony that has already been given I am going to abbreviate my own brief remarks. As you know, Michigan men are men of few words and I will uphold that tradition.

Even though it is going to be impossible to avoid some repetition. My perspectives regarding the nature of the needs of mineral engineering education are recent and were developed over the past 4 years

through considerable study. Shortly after I assumed the position of dean of engineering at Michigan Technological University in 1967 the College of Engineering was expanded to include the departments of mining engineering, metallurgical engineering, and geology and geological engineering. It was therefore incumbent on me to learn in some detail the needs of the minerals field and the role of education in meeting those needs.

Parenthetically I should add that during each of the past 3 years my institution has graduated the largest class of metallurgical engineers in the United States and we rank second in mining and geological engineering. Also we have for several years operated a productive Institute of Minerals Research, using several hundred thousand dollars of State funds.

It became apparent almost immediately that minerals education nationally was in an appalling state, suffering from advanced chronic anemia. Financial support from the Federal Government was almost totally lacking, and while other areas of engineering and technology had been by comparison receiving at least adequate support, the minerals area was on the verge of starvation.

Fortunately for the Nation, this state of affairs has now been recognized, as evidenced by S. 635, and those who have long struggled to keep alive at least the vestiges of a minerals education and research program have reason to hope that the support so desperately needed may be forthcoming.

Massive support, such as that proposed in S. 635, is needed to refurbish the minerals education establishment, attract additional able engineers and scientists and motivate young men and women to prepare themselves for careers in the minerals industries.

New technologies must be developed and increased effort must be expended on adapting the advanced technologies of other fields to the needs of the minerals industries. The new constraints imposed by requirements for safe mines, fulfilling work, a clean environment, and optimum use of our minerals resources dictate that the minerals industry become a high-technology industry in the strictest sense of the word, utilizing advanced techniques and methods not yet on the drawing board. It is not inappropriate to rank the sophistication of technological needs of the minerals industries with those of the space program.

In its own way each must be a high-technology industry. The minerals education programs cannot be rejuvenated overnight nor can a viable engineering research and development effort be mounted without the assurance of adequate funds, available over a reasonably long period of time. We must get started, and soon.

The provisions of Senate bill 635 are admirably suited to the needs of mineral engineering education and to development of a strong base of minerals technology. In the interests of the well-being and security of the United States, it is to be hoped that the bill will become law.

Thank you very much.

Senator Moss. Thank you, Dr. Kent, for your addition to our record pointing out the great needs for additional training and research in this field of minerals. The need is so universal and obvious that it does seem we are underlining it again and again, but to come from men with responsibilities such as you, Dr. McBride and Dr. Lutz, have indicated

that we have allowed the situation to deteriorate to a point where we do need some correction of it. I appreciate having your statement in the record.

Do you have any questions?

Senator ALLOTT. I just wanted to join in the chairman's remarks. We appreciate this very much, could I ask this just for the sake of context: How many students do you have at the Michigan Technological School?

Dr. KENT. About 4,800 head count. Fifty-one of those are in the department of mining engineering. Our school was founded in the late 1880's as a mining school, but it has flip-flopped.

Senator ALLOTT. So it has been reoriented to some extent?

Dr. KENT. Yes. We are graduating eight or 10 a year. We place No. 2 nationally in that category.

Senator ALLOTT. Thank you very much.

Senator Moss. Thank you. Now we will hear from Dr. Lutz, dean of engineering, South Dakota School of Mines.

STATEMENT OF DR. CARL LUTZ, DEAN OF ENGINEERING, SOUTH DAKOTA SCHOOL OF MINES AND TECHNOLOGY, RAPID CITY, S. DAK.

Dr. LUTZ. Mr. Chairman and members of the committee, my name is Carl F. Lutz. I am vice president and dean of engineering at the South Dakota School of Mines and Technology, located at Rapid City, S. Dak. I am speaking for the passage of Senate bill 635.

South Dakota School of Mines and Technology (hereinafter called "Mines")—I hope the honorable Senator from Colorado will keep this in mind when I say "Mines."

Senator ALLOTT. We always indulge people in self-pride, even ours.
[Laughter.]

Dr. LUTZ. This institution typifies the development of colleges which charted a course of mineral-related education. Created by an act of the Legislature of Dakota Territory on March 7, 1885, "Mines" offered programs in mineral education and served the territory and then the State of South Dakota in the development of the mineral resources. Nonmineral related technical programs were introduced as State support became available.

We heard much discussion this morning on this subject and I will not repeat what has been said. Enrollment has suffered in these fields. During this century, many political and technological developments have directed national attention away from the mineral fields.

Public visibility of mineral education became obscured by Federal policies which placed heavy emphasis on developing graduate training programs and research institutes in nonmineral related areas. A recent example is the Water Resources Institutes throughout the country. Parents, teachers, and students became enamored with such things as electronic developments and space exploration which have led to a severe problem in communicating to the public the challenges facing the Nation in developing our mineral resources.

Schools of mines began to experience enrollment problems and many geological, metallurgical, and mining engineering programs were terminated throughout the country, terminated not because of their lack of importance to our national welfare, but terminated because

of a lack of public policy which would have made these fields attractive to our youth. Under these conditions a manpower shortage will always exist.

"Mines" in Rapid City is a technical institution. The enrollment consists of 1,200 engineering and 400 science students. Although a small college, it can be thought of as a sizable engineering school. Approximately 18 percent of the engineering enrollment is in the fields of geological, metallurgical, and mining engineering. The primary mission of "Mines" is undergraduate education with the realization that a strong but small graduate program must be present to maintain a quality undergraduate program.

I would like to stress in my comments to follow that "Mines" is an undergraduate institution, its primary mission is the education of students with the bachelor's degree but with the realization that a strong undergraduate program cannot exist without an accompanying graduate program.

So we are projecting a strong but small graduate program at the School of Mines in Rapid City. Public higher education is becoming more cost-conscious and small high-cost programs such as the mineral-related disciplines are under scrutiny.

The expense of these programs is not inherent in the type of training required, but results from the fact that low enrollments lead to less efficient utilization of resources. For example, if 80 mining engineering graduates were produced annually from a single school, that particular program would be reasonable in cost. All mineral-related programs in the country are high-cost in comparison to other engineering disciplines because of low enrollments. It is becoming increasingly difficult to defend these high-cost programs in the face of State legislative pressure to economize.

The size of a program also bears directly on the quality of a program. State appropriations are formulated in terms of student enrollment. Staffing of a department is dependent on the departmental enrollment. It is extremely difficult to have the technical diversity in manpower required to achieve a quality program when formula budgeting dictates three- and four-man departments.

For the past 18 months, the South Dakota regents of higher education have been developing a master plan for the system. An overriding consideration in its development has been to improve the quality of education through a better utilization of resources brought about by the elimination of unnecessary duplication and the curtailment of high-cost programs.

One program studied was engineering. We have two engineering schools in the State and a recommendation from the study committee came up with the recommendation that we should have one engineering program within the State because of its high cost in relationship to other academic programs.

The committee also stated, "The low enrollment high-cost programs should be studied as to their need. Perhaps a consolidation or elimination of some of these departments is in order. Geological, metallurgical, and mining engineering are in this category."

It is ironic that our mining engineering department ranks high in the Nation in the number of bachelor's degrees granted but it is viewed as a possible liability on the State's ledger sheet. Enrollments can be

increased as evidenced by an active recruitment program, aided by scholarship incentives, in our metallurgical engineering department this year. One institution or one State cannot markedly change the trend in career choices. National policies with financial backing can make the difference.

Of course with the financial backing accompanying it, I have stressed undergraduate education because, first, the public and private organizations responsible for mineral development require personnel with this degree of professional education, and, second, a progressive research and development effort is based on a strong graduate school program which must be sustained by a large pool of undergraduate students.

There is a close relationship between research and graduate level education and mission-oriented agencies. In the case of mineral-related areas, it has been extremely difficult to obtain research support. "Mines" metallurgical graduate program centers on extractive metallurgy which includes mineral processing where only a modicum of support has been available for fundamental and science-oriented studies. The funding of mining engineering research in certain vital areas is totally inadequate. We have met with utter frustration when we seek support for research related to real problems in the mineral industries.

The Bureau of Mines is the logical agency to provide support to mineral-related academic programs. Until recently the Bureau did not have the authority to fund research. Senate bill 635 is a major step in providing the needed support for the critical situation facing mineral resources education.

I would like to discuss some implications of bill 635 as it would affect mineral-related programs and in particular the South Dakota School of Mines and Technology.

1. Student enrollment will increase in mineral-related programs. The establishment of a Federal institute of mineral resources at "Mines" would have a dramatic influence on student career choices.

2. The future of mineral resources education would be assured. The increased enrollment would result in a more efficiently operated program and legislative pressure to eliminate high-cost programs would disappear.

3. The quality of mineral resources educational programs would increase. The increase in the number of faculty members resulting from increased enrollments and from available research support will provide the expertise required for a quality program.

4. Research support in mineral resources will permit mineral-related disciplines to study problems of interest to both the Nation and the educational programs. Most Federal agencies are unsympathetic to mineral resources research since it falls outside of their primary mission.

5. Sufficient schools of mines and minerals currently exist to fulfill the national needs for manpower and research. At "Mines" our mineral engineering departments could easily enroll five times the number of students with very little increase in total operating costs and with a corresponding decrease in unit costs of instruction.

On the basis of the number of graduates from these schools, the situation must be the same nationwide. These schools have been located in geographical regions where mineral development is active and hence the citizenry has been exposed to mineral industries and

political developments relating to minerals since their youth. All of the necessary conditions are present to operate a successful program in harmony with the mission of the Bureau of Mines.

In addition, one other fact bears mentioning, and this is that four States contiguous to South Dakota do not offer programs in the mineral field. It seems desirable that some program be initiated whereby nonresident students from these States be allowed to attend "Mines" without suffering financially. Measures for this might be introduced into the program that is envisioned.

Senate bill 635 provides the funds for academic research and educational training to an agency, the Bureau of Mines, whose mission is parallel with the schools of mines. I congratulate Mr. Osborn, the Director of the Bureau of Mines, for coming to the aid of mineral education. The development of the Nation's mineral resources in a wise manner can be furthered by the passage of this bill.

I want to thank you for being allowed to present this testimony.

Senator Moss. Thank you for your testimony and for pointing out the situation at the School of Mines in South Dakota. You point out that you have room for more students and on a unit cost they could be educated at lesser cost than the ones you are turning out now by utilizing your facilities fully.

It certainly seems that we must take the opportunity presented by S. 635. All of the testimony is that we are suffering from a lack of trained engineering personnel who come into the mines and minerals field. The figures we had this morning, on the small number of graduates that will be coming out is frightening.

We are glad to have you make this point for our record. You follow along somewhat the same suggestion as the other two gentlemen on this panel, that there ought to be some way to enable students in States where they do not have an established and operating school of mines to enter in a school that is operating and established and capable of providing the courses without suffering these out-of-State penalties that have grown so large, Dr. McBride told us about Colorado and it is the same all around.

It is a problem we must address ourselves to. I do thank you for coming to give us your testimony today.

Senator Allott.

Senator ALLOTT. A couple of things.

Doctor, it seems to me that in this area we are to some extent in a situation of which came first, the chicken or the egg. My purpose in introducing S. 719, the National Minerals Policy Act, in the first instance was because I saw through tariffs, trade barriers, lack of attention to our minerals industry, a deteriorating mineral industry in the United States.

It was deteriorating basically because of economics, of course. We have learned that we can produce most everything we want to in this country if we are willing to go after it. But the purpose of that bill was to foster the development of an economically sound and stable domestic mining, minerals, metal and mineral reclamation industry in this Nation.

Now that we have established a basic policy for the Government, which is the first time that the Federal Government has ever had a policy with respect to our minerals, I anticipate that with this and other pieces of legislation, lest anybody think this is the beginning of

the end, I want to assure you this is not the last bill to be introduced to implement S. 719. I think that what you have had to say about the high cost of students is very significant. I want to ask you, therefore, this question: What steps have you taken, through whatever your governmental supervising agency is, whether it is the State Board of Education or whatever it may be, toward seeking cooperative arrangements with other States who do not provide mineral education?

I am thinking particularly of the arrangement which exists, and I am not sure I am speaking now of the present situation, but at one time we had a school of dentistry at the University of Denver which was later abandoned and about the time I came to the Senate we had negotiated agreements with surrounding States, including the great State of Utah to our west, that we would establish a dental school in Colorado which is just now coming to fruition.

Those States would contribute the tuition costs to the students who came to the dental school. Now, if this can be done in dentistry, cannot it also be done in mining?

Dr. LUTZ. I would hope it would, within South Dakota we have a similar arrangement in the Federal fields. The same thing with respect to dentistry. I feel that this type of cooperation is healthy and it makes sense in the light of our financial conditions within higher education.

Within the mineral industries, I would very much like to see a cooperative program, as Dr. McBride said. I think we have pretty much of our population for the mineral industry field within South Dakota. I think we could amply take care of many out-of-State students within our program and some arrangements should be arrived at to accomplish this.

Senator ALLOTT. I am not sure at the present time if we were to establish a mining school in every State of the Union we could absorb all of the students that could be graduates and I see you shaking your head, and I see you agree with me. Therefore it seems to me we are isolating part of the problem here, to try to supply the proper number of mining, geological, metallurgical, and so forth, students, but to do it on the basis where it actually is of less burden to the States which are maintaining schools and which in turn will produce and enable you to produce even a higher quality of graduate and maintain a higher level—not that you are not doing it now, you understand that—but the whole thing just enables you to upgrade the whole education in these fields, would it not do that?

Dr. LUTZ. Yes; it would.

Senator ALLOTT. Well, I hope you would explore that program, because it seems to me it could be very productive and to any other gentlemen here, I think this sort of cooperative program with other States, I think, would be very productive.

Senator MOSS. Thank you very much, Dr. Lutz, Dr. Kent and Dr. McBride. We do appreciate having you come to testify for us.

Senator ALLOTT. Let me say, Mr. Chairman, of course Dr. McBride addressed himself to this, because the bill does provide that two or more States can cooperate in the designation of an individual institution. But someone has to instigate and get them moving to cooperate.

Senator MOSS. Dr. John Morgan is the consulting mining economist from Daytona Beach, Fla. I am very glad to have you, sir.

STATEMENT OF DR. JOHN D. MORGAN, JR., CONSULTANT,
DAYTONA BEACH, FLA.

Dr. MORGAN. It is a pleasure to appear before the committee and give my views on the present bill. Having been connected with matters of national mineral policy since 1948, as a Government official prior to and during the Korean war, as a consultant to industry and government after 1956, and in 1966-69 as chairman of the panel on Mineral Economics and Resources of the Committee on Mineral Science and Technology of the National Academies of Science and Engineering, I deeply appreciate the opportunity to present my views on S. 635. The act of 1970 is a great step forward toward the urgently needed ongoing, forward-looking, comprehensive national mineral policy and implementing programs that are required for continued functioning of the Nation's high-level industrialized economy. S. 635 will extend and contribute importantly to the authority of the act of 1970.

The earth is the source of all primary wealth. The crust of the earth, and its seas, and its atmosphere are the basic source of everything we use. Most agricultural materials can be renewed in growth periods measured from a few months to a score of years, but mineral resources are the end product of natural processes that must be measured in millions and hundreds of millions of years. Consequently, mineral policies and programs must be formulated in recognition of this fundamental difference.

World demand for minerals is rapidly rising. We heard considerable testimony today on the United States. I want to point out that is part of the problem, but an even more important thing is the overall world situation. Our economy is highly dependent upon adequate supplies of metals, minerals, and fuels, and we are becoming increasingly involved in the burgeoning world economy that is combing the earth for mineral supplies.

In the table in the testimony here I have compared the economies of four leading industrialized areas of the world. Last year the United States produced 131 million tons of steel and we consider that as the major single index of the country's industrialization.

	Area (million square miles)	Population (millions)	1970 steel production (million tons)	Gross national product (GNP) (billions)
United States	3½	205	311	\$1, 018
Common Market (France, Italy West Germany, Benelux)	½	200	125	500
Japan	¼	100	93	200
U.S.S.R.	8½	240	127	±500

The Common Market, Japan, and most other industrialized nations of the free world are highly dependent upon imports of minerals, while thus far the United States has managed to obtain the bulk of needed supplies from its own 3.5 million square miles, with imports playing a supplementing role, except for a number of "strategic and critical materials," for which imports supply significant percentages of total usage.

Senator ALLOTT. Can I insert a remark at that point apropos of your table. I heard an economist, I perhaps should not attribute this because it was in a closed session, within the last week say that he expected at the present rate that Japan would surpass the steel production of the United States by 1980.

Dr. MORGAN. This is quite possible, sir, if you notice the number on Russia there, they are at 127 and we at 131. They could surpass us this year.

Senator ALLOTT. Thank you.

Dr. MORGAN. In contrast, thus far the U.S.S.R. has followed a national policy of mineral autarchy (self-sufficiency), but the rising demands of its 240 million people plus the additional 100 million in its satellites for higher standards of living may soon force the U.S.S.R. also into a wider role in world mineral markets.

Further, the rapidly multiplying impoverished billions of people in the underdeveloped nations of the world can only hope to have some improvement in their standard of living through greatly increased supplies of agricultural and mineral products.

Supplies of many minerals are harder to acquire. At the same time that demand for minerals is rising, supply sources that were once readily available to the United States are declining. Within the United States itself, the surface has been extensively prospected and far more extensive geological, geophysical, and geochemical work is required to find new deposits, and more advanced techniques of mining, beneficiation, smelting, and refining are needed to cope with lower grade deposits.

Outside the United States, many areas once considered wholly reliable sources have changed their politico-economic orientation. Cuban nickel, recently extensively developed by the United States, now flows to the Soviet bloc. Chilean and Peruvian copper developed by U.S. firms is being expropriated.

The price of Mideast and Venezuelan crude oil was just raised substantially. Unrest in parts of Africa threatens hitherto reliable sources there. Meanwhile, in several important cases, U.S. stockpiles would suffice for only a very short period of time if normal supplies were to be interrupted by unrest, strikes, sabotage, or economic warfare. For example, the 250,000 tons of copper on hand represent only 1½ months' normal industrial usage in the United States.

Minerals support 10 percent of the GNP; hence governments and citizens must understand their critical role in the economy. The role of metals, minerals, and fuels is far more important in our economy than the bare statistics would seem to indicate. I am personally of the belief that the mineral industries account for in the vicinity of 10 percent of our GNP. Yet in 1970 the Department of the Interior valued mineral industry output at only \$29.5 billion, or only about 3 percent of the GNP.

How can this be? It is simply that the official statistics of the USBM, and I mean absolutely no criticism of them here, they did a beautiful job in this field, reflect the division of responsibility among a multiplicity of agencies, as listed in the table on the next page, and the USBM has dutifully and properly priced out each mineral commodity up to the point where USBM delegated authority stops, but the value added by the industry to make a usable product shows up in the GNP in statistics furnished by the Department of Commerce, which is the delegate agency for manufacturing industry.

Two major examples will suffice to illustrate this point clearly. The USBM valued United States 1970 production of 88 million tons of iron ore at \$935 million, but in 1970 the United States added 100 million tons of steel products to its economy, which, conservatively valued at \$150 per ton, would total \$15 billion.

In petroleum, the USBM valued 1970 U.S. production of 3.5 billion barrels of crude oil at \$11 billion, which would be slightly over 7 cents per gallon. Yet I pay in the vicinity of 23 cents per gallon for fuel oil and 32 cents per gallon for gasoline, and in 1970 the United States used about 4 billion barrels of petroleum. Hence, the petroleum industry alone probably contributed from \$30 to \$40 billion to the U.S. economy from oil alone.

Just parenthetically, as a doublecheck on that figure, I added up the business done last year by the leading oil companies on the New York Stock Exchange and that totaled \$64 billion. So that is a check on the figure. Consequently I conclude that the mineral industry in its entirety must contribute about \$100 billion to our \$1,000-plus billion GNP, or 10 percent.

Therefore, our efforts to understand and support the mineral industry must be strengthened. As these numerous agencies consider taxes, tariffs, customs, canal tolls, safety regulations, pollution controls, et cetera, et cetera, they need extensive studies in mineral economics and mineral politico-economics.

Further, in each of the 50 States of the United States there are usually at least two State agencies concerned with the mineral industry—a geological survey and a mining bureau as listed on pp. 47-49 of our NAS report, "Mineral Economics." These agencies, too, need extensive expertise in dealing with mineral problems.

Further, the general public, too, must understand the pervasive role of the mineral industry. At present there is a great misinformed cry about our using up our minerals. True, burning some of the fuels may represent an irretrievable use, but most minerals and mineral products represent rather the conversion to more useful forms that will contribute to man's standard of living for long periods of time.

For example, in 1970 U.S. industry converted 2 million more tons of copper to useful forms, but our actual usage of copper is probably in excess of 40 million tons, counting all that is in place in the form of wires, piping, motors, brass, bronze, et cetera.

And then, when a building is torn down, or a motor scrapped, the salvage of copper and copper-base alloys for recycling is routine. In the same manner, steel, aluminum, cement, ceramics, et cetera, are not used up annually at all, but rather are put into place for enhancement of human life for periods that may extend over generations.

The science of mineral economics is in its infancy. Policies and programs must be based on facts. Facts must come from accurate and timely data. Data must be developed through planning, organization, and research. The Federal and State agencies, financial institutions, companies in the mineral industry, and companies connected therewith, all need better understanding of mineral economics. And all need better arrangements for closer cooperation in the exchange of information.

At present only one university in the United States offers undergraduate and graduate degree programs in mineral economics—that is the Pennsylvania State University. The Colorado School of Mines

recently instituted a graduate program therein, and the University of West Virginia is currently planning to expand its work in mineral economics.

Some universities and colleges give courses in mineral economics, mine valuation, economic geology, et cetera, and from time to time some theses and dissertations in law, economics, political science, business, management, et cetera, have been written on mineral economics subjects. The Resources for the Future Foundation has sponsored a number of studies in the field. However, the total effort is very small, and the need for greatly increased research and education as documented in the 1969 NAS study "Mineral Science and Technology—Needs, Challenges, and Opportunities" is becoming more critical each year. Hence I strongly support enactment of S. 635, aimed at strengthening education and research in all mineral disciplines, including mineral economics.

Thank you, sir.

Senator Moss. Thank you, Dr. Morgan, for your excellent paper pointing out that the demand here in the United States as well as the world for minerals and mineral products is rising and that the demand will probably rise faster overseas than here.

I understand that our consumption is now far and away greater than any other country in the world. I appreciate your outlining what the real problem is and what we must face.

When you say mineral economics is in its infancy, that indicates that we certainly need S. 635 to move into a position where we can attack this problem and provide trained manpower to do the job for us.

Dr. MORGAN. Yes, sir.

Senator Moss. I thank you.

Senator Allott.

Senator ALLOTT. I want to thank you very much, Doctor. Your paper has been very useful in providing a sort of broad outline to the whole field in comparison with the relatively narrow aspect of S. 635, and you have recognized that, and therefore, I think your remarks and your analysis have been particularly useful in this hearing. I appreciate it.

Dr. MORGAN. Thank you, sir. It has been a pleasure to appear before you.

Senator Moss. Thank you.

Dr. Newman Hall, executive director of the Commission on Education, National Academy of Engineering in Washington. Dr. Hall, we are pleased to have you, sir, and we look forward to hearing from you now.

**STATEMENT OF DR. NEWMAN A. HALL, EXECUTIVE DIRECTOR,
COMMISSION ON EDUCATION, NATIONAL ACADEMY OF ENGI-
NEERING**

Dr. HALL. Thank you very much, Mr. Chairman. It is a fortunate opportunity for me to be able to appear before you today and to add my support for the pending bill, S. 635. In today's atmosphere of resource and environmental crisis, it is most reassuring to find a legislative proposal which gets at truly basic factors and avoids the all too familiar focus on superficialities.

I am appearing here personally because of an intensive study which I have made for some 20 to 25 years on engineering education in this country. I have had the privilege of visiting on the campus of almost every engineering school in this country, including all of those represented here today, and many foreign institutions, including some half dozen institutions in the Soviet Union.

I would also like to speak on a much broader basis with regard to the total engineering problem rather than just mining and mining schools. I do regard the situation here on this bill in a certain sense a prototype with regard to needs that are much broader. Hopefully this bill will be passed and the changes will occur in mining and can, in fact, point the way to much of what is going to happen throughout.

During the past 25 years one of the major developments in engineering education took place and provides a precedent for the next change which is needed and which can be implemented in part by the present bill.

Our experience during World War II showed us that advances in physical science had provided a basis for technological developments of major importance and consequence. It was clear that the education of the engineer must be radically changed so that he could make effective use of new scientific knowledge.

Furthermore, the payoff from scientific research had been so dramatic that we were persuaded that a major investment in support of research in pure and applied science was in the national interest. We made this investment. We are all familiar with the support for scientific research provided by NSF, NASA, DOD, and other Government agencies.

Much of this support was received by engineering schools, and consequently an increased emphasis on scientific principles occurred. Stimulated by a steady flow of funds, the graduate research activities in applied science in engineering schools has grown almost exponentially.

As a consequence, the complexion of these schools has almost totally changed. To the extent that a much-needed strengthening of the scientific basis for technological development was provided, this has been good.

However, not unexpectedly, there has been a tendency for this growth in applied science to become an end in itself. There has not been a sufficient effort to maintain the essential balance between science and engineering required to serve the public interest. As a consequence, while we have moved forward in scientific knowledge in many areas, our technological capability has stagnated unfortunately in many cases where the public and economic need is greatest today. The task at hand is to restore the balance so that there can be a sufficient capability in engineering to make effective use of scientific resources.

This imbalance is particularly evident in the case of minerals resource development. During the past 25 years, attention in our engineering schools and their research and development centers has been increasingly directed towards scientific aspects. There have been significant advances in physical metallurgy and solid-state physics.

At the same time, there has been a consistent neglect in these centers of the operational areas such as extractive and process metallurgy. Mining engineering enrollments both at the undergraduate and graduate levels have deteriorated. As an engineering discipline, which is intrinsically concerned with operational practice rather than scien-

tific research, it has become increasingly unpopular and has received a very small share of development funds.

During the past several years, the Commission on Education of the National Academy of Engineering, of which I am associated, has been turning its attention to the type of situation illustrated by the present problem in the area of mineral resource development.

It has been particularly concerned with this question of balance, since it is essential that we maintain and strengthen our established gains in science while at the same time we move forward much more strongly in engineering development. Our domestic and international economic strength is highly dependent these days on our technological capability. This can only exist if our engineering education is well supported.

Let me be somewhat more specific with regard to the educational program in engineering. In order to accommodate the necessary increase in emphasis on basic concepts in science, the educational program of the engineer at the undergraduate level has become much more dominantly science-oriented in recent years.

This has been accomplished by transferring from the curriculum training in skills to engineering technicians. Also, it is increasingly accepted that the engineer can continue his education beyond the 4-year undergraduate program. Recent studies, including an NSF-supported study conducted by the American Society for Engineering Education, recommended that generally the first professional degree in engineering should be at the graduate level.

Unfortunately, this trend has occurred at a time when the emphasis in graduate studies in engineering has remained overwhelmingly in the direction of science rather than engineering practice. Consequently, the engineering schools have been unable to serve the real needs of the profession and of society at an advanced level.

It is not possible nor desirable to move back to a former period when the technological needs of society could be met by a simpler education for the engineer. Today his education must be adequate for today's needs or else he will not be able to do the job. Society will thereby suffer. It is already clear that we do not have the engineering manpower sufficient to give proper attention to the problems in mineral resource development.

The greatest need at this point is a recognition that there can and must be established at the graduate professional level a program of support for engineering development projects. The pending bill, S. 635, makes basic provision for this in the minerals field.

Such a program can serve several essential purposes. It can provide a sound financial base for students and faculty in the advanced educational program. It can enable the engineering and mining schools to carry forward development studies which will contribute to economic growth, to meeting the material resource needs of society, to wise utilization of these resources including recycling, and to the preservation of the environment.

All of these are solid engineering tasks. The development centers for their accomplishment must be supported and a strong advanced educational program must be stimulated and reinforced.

Last summer, supported by the NSF, the Commission on Education of NAE conducted a workshop on the theme "Social Directions for Technology." Recognizing the need for more powerful methodologies

in engineering analysis and design and for a greater capability in technological manpower, a major recommendation of this workshop calls for the support of centers which will conduct engineering development studies and projects in the public interest.

(The workshop theme referred to above is in the Appendix.)

The passage of the pending bill could provide an initial step in implementing this recommendation and at the same time contribute very specifically to bringing to bear the talents and resources of the engineering schools on the host of problems facing the minerals industry, ranging from safety to recycling.

More recently, on March 25-26, 1971, the Commission on Education in cooperation with the Bureau of Mines assembled a panel of leaders from engineering and mining schools to review the needs for a program of mineral resource development in engineering schools. We have in process a report of this meeting and I hope it will be possible to include this in the record.

Senator Moss. If it is prepared in time we would certainly like to have it.

Dr. HALL. The preliminary findings of this group recommend that:

1. There be flexible, continuing support for programs of research and for development of able, qualified graduates, faculty, and practicing engineers for the field. Specific research programs in the form of projects would be funded by "Minerals Projects Grants." Support for institutions for the development of a sound base for engineering education in the field would be in the form of "Minerals Technology Awards" and support of programs of development or improvement of an individual's technical competence would be made in the form of "Minerals Technology Fellowships."

2. Proposals for all types of grants would be evaluated on the basis of merit, and the potential for long-term enhancement of the capability of mineral resource development in the United States. The evaluation of proposals and the decisions on awards of support should be based on the established mission of the Bureau of Mines, but independently of existing research programs and funding within the Bureau.

3. An Advisory Committee on Policy for Education in Mineral Science and Technology should be established. This committee would assist the Director of the Bureau of Mines in the formulation of policy and would advise the Office of University Affairs of the Bureau on policies relating to the appraisal of proposals and evaluation of the performance of programs supported by grants and awards.

4. Interdisciplinary activities on projects and programs should be encouraged, where appropriate, between the engineering departments concerned directly with mineral resources development and other departments in the educational institution.

Further study will be required to formulate other recommendations more conclusively. It is clear, however, that the proposed bill, S. 635, can represent a major step in making possible the implementation of these well-considered recommendations.

May I summarize by observing that the establishment of strong engineering development centers, dedicated to the practical attack on problems of mineral resource development, can be one of the most meaningful forward steps in serving the pressing needs of society.

This can be a significant response to the oft-heard complaint that we can go the moon, but that we can't handle our immediate problems.

To revitalize the capability of our educational institutions so that they can direct their energies to the practical needs of society can provide a vehicle for worthwhile action by our young people who have too often been exhorted by hollow emotionalism. A job needs to be done—let us build the engineering capability to get on with it.

Thank you, Mr. Moss.

Senator Moss. Thank you, Dr. Hall, that was a very fine statement and I am glad to have you point out the need for engineering training and graduate engineers to put to work our scientific advantages. I think what you pointed out is undoubtedly true, that the scientific research end is overbalancing the engineering and that the engineer is the nuts and bolts man who makes it all work and puts it to use. Certainly we need that greatly.

So I am glad to have your endorsement of the bill and your suggestions that will help us in refining it and perhaps in persuading our colleagues quickly to pass it. Thank you very much.

Dr. HALL. Thank you.

Senator Moss. I am going to ask Dr. Reid of the University of Idaho, Dr. John Elliott, Massachusetts Institute of Technology, and Prof. Thomas Falkie of Penn State Department of Mineral Engineering at Penn State if they will come to the table now.

We will hear them as a panel. Professor Hassialis of Columbia was unable to come but he has provided us with his statement which will be placed in the record in full.

(The statement referred to follows:)

STATEMENT OF M. D. HASSIALIS, KRUMB PROFESSOR OF MINING, HENRY KRUMB SCHOOL OF MINES—COLUMBIA UNIVERSITY

Mr. Chairman and Members of the Subcommittee: Permit me to preface my comments by recording my hearty endorsement of the Bill S. 635. Its avowed purposes of encouraging and supporting research and the training of personnel in the minerals fields are major factors in the implementation of the Mining and Minerals Policy Act of 1970.

I am certain that the increasing need for engineers in the mining and minerals fields which closely parallels the increasing rate of consumption of ores and metals is adequately and convincingly documented by the literature which has been made available to this committee. I have taken the liberty of making available copies of an article which was part of the symposium entitled "Training for A.D. 2000" conducted by "The Mining Magazine" of England. In this article I have attempted to discuss some of the reasons that enrollments in mining, mineral engineering, and extractive metallurgy have failed to respond to increased demands for engineers in those fields. Today I would like to take advantage of the opportunity which has been afforded to me to discuss the role of research in the training of minerals engineers and in advancing knowledge in these fields.

Research which involves students is fundamentally a teaching tool which incidentally develops new knowledge and therethrough new and improved understanding. It is the educational device by means of which the student is weaned from the nourishment of knowledge supplied by his teachers. It is the educational experience whereby he achieves the greatest professional maturity short of the maturity which comes from the practice of his profession in the industrial world. When he embarks upon this experience he is still largely dependent upon his teacher for guidance and knowledge; as he acquires knowledge in the area of his research, he becomes a colleague to his teacher; and finally when he completes his research he becomes in fact the teacher, and his former teacher, the student in the research area. In the course of this experience he has learned to identify problems, analyze these problems into their subsidiary parts, determine the new knowledge that will have to be developed to resolve the subsidiary questions and finally synthesize an answer to the problem under research. He learns to stand on his intellectual feet and he gains confidence in his own abilities. Additionally, and of equal importance, his creativity is unshackled from the

psychological bonds most students experience when they are acquiring the knowledge developed by their teachers and predecessors.

Research in the minerals fields is of many types and performed by different groups. The research done by equipment manufacturers—with one or two notable exceptions—is really developmental work. The research done by industry and contracting research institutes is largely “application and testing research.” In recognition of this fact and as a remedy thereto, companies have banded together to form organizations—e.g. the American Iron and Steel Institute—to support research for the industry as a whole. The more fundamental and basic research is done largely in the universities and schools of mines and to some extent in the laboratories of the Bureau of Mines. But the extent of this type of work is woefully small. There are many reasons for this situation. There is an old cliché which says that no two ores are the same and no two mineral properties are identical. Despite its triteness it is true. The result of this is that when a company does research connected with the development and exploitation of a mineral deposit, its efforts are directed more towards the peculiarities of the deposit and the ore. True, the information thus developed will in time add to the totality of knowledge and, in the hands of a researcher interested in the why's and wherefor's and the relationships existing between the variables of the system under study, can serve a very important purpose. But this knowledge is made available much too slowly, for initially it is classified as company confidential.

The research which is directed at improving our understanding as to how and why things work, though aware of the peculiarities of individual ores and deposits, generalizes these idiosyncrasies. It is this research which will convert the arts of the minerals fields into technologies and ultimately into applied sciences. It is this research for which the support from government and industry amounts to little more than tokenism. If my reading of the intentions of the Bill S. 635 is correct, it is this research which will now be strongly and vigorously supported.

Permit me to make a further distinction. The phrases “fundamental and basic research” have many meanings. Following the end of the second world war a change has taken place in the direction of engineering education. Increasingly it has taken on the aspects of an applied science, and the teachers of these programs have increasingly been recruited from the science fields. The research interests of these teachers is also fundamental and basic research. The problem-orientation of engineering research has waned; it is more “curiosity-oriented.” Without mitigating the value of such research, it is my opinion that what the minerals fields need is problem-oriented research—and it is this type of research which should be used to complete the training of minerals engineers if their final degrees are to indicate *professional* attainment.

Another reason for emphasizing the problem-orientation of research in the minerals fields stems from the fact that many of our new ideas represent adaptation of knowledge developed in other fields. Thus the ion-exchange and solvent-extraction processes had their origins in chemical techniques. The adaptation to problems in the beneficiation of uranium ores was made possible by the strong support of U.S.A.E.C. directed at the problem of recovering uranium from low-grade ores. Another adaptation currently taking place is the use of the systems approach and operations research to operations and management in the minerals fields. Of equal importance is the use of computer methods in the organization and assimilation of data and ultimately in the automatic control of operations. These and other adaptations are made by problem-oriented research.

Finally I would like to repeat the well-known fact that the U.S. is a have-not nation with respect to its general minerals requirements. It has been said that we have exhausted most of our economic ores. I do not subscribe to this viewpoint. Many mineral deposits exist which are uneconomic under the present price structure and with the present state of our knowledge. It is my conviction that many of these deposits can be made economic by developing more effective mining and beneficiation techniques. Following the first world war, it was said that the U.S. had run out of economic lead ores. When the flotation process was introduced, this situation changed overnight. Today, we are still mining lead ores and producing lead metal. The same is true of the low-grade porphyry copper ores: with the development of very efficient mining methods and beneficiation methods these deposits became economic and today are an important factor in the copper production of the U.S. Additionally, the exploitation of these ores has pointed the way to a new concept, i.e., the viewing of an ore not as a simple metalliferous ore but as a multicomponent ore. It should be pointed out that our dependence on imports for many of our minerals requirements is an important factor in the trade-balance

of the U.S. These imports have been increasing at an alarming rate. Any effort which can convert uneconomic into economic deposits by the development of new methods and technology is of great national importance; indeed, one might say it is a national imperative.

To summarize, the creation and support of institutes for research in the minerals fields affiliated with educational institutions will have the following beneficial effects:

1. It will improve the recruitment and retention of high-quality teachers.
 2. It will attract students to the mineral engineering programs for the governmental support will underline the importance of and opportunities for careers in the mineral industries.
 3. It will increase the production of graduates well-trained in the technologies of the minerals fields and capable of independent and creative work.
 4. It will accelerate the assimilation and adaptation of knowledge developed in other fields.
 5. It will help to increase the economic mineral reserves of the U.S.
 6. It will make an important contribution to the balance-of-trade and there-through to the balance-of-payments of the U.S.
 7. It will improve the efficiency and effectiveness of the minerals industries.
- Finally, and most importantly, it will go a long way in improving the tarnished image of the minerals industries by showing the people that our government is deeply concerned with one of our most important natural resources and that it intends to do something about it.

SUMMARY

The establishment and continued support of institutes for research in the minerals fields marks a turning point in the implementation of the Mining and Minerals Policy of the US. Therethrough it will increase the production of trained engineers in these fields; it will attract and hold qualified teachers; it will help to develop knowledge that may increase the economic mineral reserves of the country and thus have an important impact upon our balance-of-trade; it will contribute importantly to the abilities of the relevant industries to operate more safely, more efficiently and in better harmony with the environment; and finally, by complementing the activities of the Bureau of Mines, it will serve to infuse a new spirit and determination in this agency which has been charged with one of the most important functions, i.e., to promote the development of the mineral resources of the United States.

The Enrollment and Employment Problem of Mining

by PROFESSOR M. D. HASSIALIS*

DECLINING enrolments in mining curricula and an insufficient supply of engineers to meet the increasing demands of the mining industry, have been the subject of much discussion within academic halls, at professional meetings and in industrial circles. Increasingly these discussions are marked by impatience, frustration and resentment — impatience with the slowness of response of the problem to attempted solutions; frustration because these solutions appear not to be working on a short-time basis; and resentment, particularly on the part of industry, because many of the constructive steps it has taken, only after much profit-and-loss statement searching, have not been followed by appreciative response on the part of enrollees and job applicants.

There is a tendency to approach the situation as another problem in technology or economics in the hope that a few primary causative factors will be thereby established, which, upon manipulation, will cause the system to move in the direction of increasing enrolments and job applications. Unfortunately the system is far too complex for this type of approach — for it is a human system — and our concern is with the decision-making function of the individuals comprising this system. Probably no two individuals follow the same path in the selection of a profession; furthermore, no two individuals make this choice within identical circumstances; and finally, the decision-making process is non-deterministic for it has an emotional component varying in degree from individual to individual.

Before considering how and when individuals select their professions, it would not be inappropriate to ask: Is there a mining profession? What is it? Is there a need for mining engineers? In view of the topic under discussion these questions would appear to be impertinent. Certainly there is a mining industry. This industry uses many technologies of which mining engineering is but one. However, even a casual examination of the unit operations of mining soon discloses that these operations can be equally well, if not better, performed by other than mining engineers.

Only in the selection of the mining method, and in determining whether and how operating results should modify the mining method, does the mining engineer seem to have a unique role in the technology of mining operations. In the case of open-pit operations, even this role is suffering erosion by civil engineers. The other seemingly unique role of the mining engineer, is the management of mining operations but the assignment of this role is more a consequence of tradition and historical accident than professional training.

Sixty years ago the mining camp was so isolated by lack of communications and transportation that the mining engineer in charge had to be completely self-reliant. He had

to know how to build roads, run and maintain a power plant, handle all electrical and mechanical problems, service and repair equipment using the materials and tools on hand, supply and house his work force, on occasions serve as dentist, doctor and even as midwife, dispense justice, provide spiritual leadership, and healthy outlets for his men's energies off-time, etc., etc. All of these activities were directed towards a single goal — get the job done and show a profit. Engineering had not yet divided and subdivided into the specialities which exist today. The mining engineer was responsible for all the unit operations of mining.

With the perfection of planes, helicopters, radio and other means of transportation and communication, the isolation of the mining camp has virtually disappeared. It is difficult to imagine a problem arising for which a specialist and/or a specialised piece of equipment cannot be delivered at the camp site within 48 hours. In fact, each camp has its resident specialists who have taken over the detailed responsibilities previously assumed by the mining engineer. With the diminution of isolation, accountability for the mining operation has increased. Whereas previously the operation was reviewed yearly, or at best half-yearly, today accountability is at least a monthly affair. With these and other inroads on his time, the mining engineer withdrew somewhat from direct operations. In so doing, he assigned responsibility therefore and established management controls to keep him informed and in overall charge.

Today his job is essentially one of concerting the activities of various specialists responsible for the different mining operations. In the performance of his job he will be dealing with specialists in geology, ground control, ventilation, explosives, surveying, mechanical, electrical and civil engineering, communications, etc. He need not be a specialist in each of the areas in order to manage their effective co-action but he should know enough to deal intelligently with these areas. But this type of generalised knowledge could equally well be possessed by other than a mining engineer. Only insofar as his training provides the breadth of background implied above can it be said that the mining engineer is uniquely qualified. Certainly, not all mining engineers reach this level of responsibility for the overall management of a mine. Some remain at the lower levels of management and at still lower levels which may be more accurately described as operational levels. As has already happened in other fields of engineering, the operational levels are being manned increasingly by skilled technicians, and the mining engineer who stays at this level is actually under-employed.

As to the need for 'mining engineers' there is no question that such need exists today and will increase in the future. This need exists at both levels, *i.e.*, the operational and administrative or management levels. In broad terms and

* Henry Krumb School of Mines, New York.

TRAINING FOR A.D.2000

without differentiation between metals, the annual rate of consumption of ores and their derivative metals will practically double by the end of this century. Some authorities believe this may be an understatement for such consumption is proportional not only to population growth but also to increased standards of living. Considering the fact that the great majority of the earth's population has a very low standard of living compared to the small minority and that the reduction in the standard-of-living gap should be a primary geo-political goal, the above estimate of future consumption may well be an underestimate. But this increase in consumption implies an increase in demand for 'mining engineers'; not necessarily the same percentage increase, for hopefully, improvements in techniques and efficiency should increase the units of production per engineer.

Diverging Trends

We see, therefore, a rising demand curve for 'mining engineers' which practically doubles by the end of the century. Conversely, if we examine the supply curve of graduating mining engineers this shows a steady decline which reaches zero output by the mid-eighties if we are brash enough to extrapolate this curve. What has produced this state of affairs? Why do not our young people elect mining as a professional option? The reasons are so many, varied and individualistic that it is not possible to discuss them in a systematic manner.

For some ten years the author made a recruitment circuit of the New York metropolitan area. He spoke glowingly of the interesting and exciting opportunities in mining, mineral engineering and metallurgy. Yet in ten years it is doubtful whether his efforts were instrumental in deciding more than 4-6 youngsters to enter these fields. The obvious conclusion is that the speaker was ineffective. However, a comparison of notes with other speakers of unquestionable talents in the art of transferring their convictions to their audiences, showed similar, poor yields.

During this period and subsequently, by listening to young people and particularly older people, it was possible to first glimpse, then more clearly see, mining as the general public views it. To them it is an unclean, unhealthy, unsafe, unremunerative, unimaginative and unstimulating activity — in mod language, it is an un-profession. Who hasn't seen in the movies or on the front pages of his newspaper or on a TV screen, a miner emerging from a hoist cage, lunch-pail in hand, a short stubby pipe grimly clenched between teeth, a miner's light on his hard hat, with blackened or begrimed face setting off white eyes and giving to the general countenance the haunted look of a man emerging from the mysterious nether regions? Obviously a picture of man engaged in a dirty business who has just undergone a soul-searing experience.

Who has not heard of silicosis? Who has not heard of tales of mysterious ailments afflicting miners from breathing the insupportable dank fetors of the underground? Who has not guiltily thrilled to the unfolding drama of a mine disaster reported in all its gruesome details? By now the script is

standard; there are only variations on the theme. The grieving wives and mothers keeping vigil at the headframe; the hush of expectancy as the cage comes into view; the reported tappings of trapped men which keep hope alive; the step-by-step descriptions of heroic men braving noxious fumes and falling rock to rescue trapped companions — this is the stuff that legends are made of. Who has not run the gamut of emotions from pathos to exhilaration as we vicariously react to these accounts from the safety and comfort of our armchair? Certainly this is a dangerous business.

The public's view of remuneration and rewards in mining is mixed. One extreme is dominated by the picture of a forlorn group of miners waiting at the employment office; the other extreme is composed of tales of fabulous wealth amassed within a short time by people whose names have passed into history. However, this extreme is tainted by the suspicion that such rapid acquisition of wealth could only have been achieved by devious, dishonest and indelicate means. Spanning these extremes is the view that mining is a feast or famine business. The more knowledgeable still recall that a mere decade ago, graduating mining engineers were having difficulty in being employed while simultaneously their older colleagues were being laid off after years of service. They also recall that starting salaries offered to new graduates were substantially less than in other engineering fields. Certainly there is no history of steady employment at competitive salaries comparable to the situation in other engineering fields.

Art or Science?

Another picture of the mining industry held by knowledgeable and even sophisticated people, is that though mining is one of the oldest engineering professions, it is still fundamentally an art using methods and techniques not vastly different from those described by Agricola. True, there have been modifications resulting from the introduction of steel, explosives, electrical power and the like, but the methods are all too similar to those used by the Egyptians, the Greeks and the Romans. They see little difference between the continuous ore conveyors of the Roman-operated mines in Iberia and the modern bucket elevators. Whereas the Romans used a continuous rope, we use a continuous belt of leather or articulated metal units; whereas the Romans used reed baskets tied to the rope, we use metal scoops riveted to the belt; whereas the Romans used animal or human power, we use electrical power as the motivating force. They see in this only the improvements resulting from the availability of a wider choice of improved materials of construction and from new energy sources but no improvements in method as a result of new solutions to old problems.

Financial analysts evaluating different industries are quick to point out that research expenditures, if existent, are woefully small regardless of the yardstick used when compared to the more progressive such as the electronic, petroleum and chemical industries. It has also been noted that improvements follow, with a nearly unit correlation coefficient, a shrinkage in the margin of profit resulting from increased labour and material costs. This is not the picture of an aggressive, imaginative industry continuously striving for self-improvement but rather of an industry content to preserve the *status quo* and making advances in technology only when forced to.

TRAINING FOR A.D. 2000

In encapsulated form, this is the image the general public sees of our industry. We know it is a badly distorted image suffering from spherical and chromatic aberrations. Though badly delineated and highly coloured there is enough truth in it that when we attempt refutation we are inevitably led to the defensive phrase: "Yes, but —". Whether this image is true or false is irrelevant; what matters is that it is the view of the general public and to the extent it influences the decisions of young men in their selection of a profession, it must be taken seriously.

How and when do youngsters make up their minds as to their choice of a profession? How and to what extent is their decision affected by the general public's view of mining? It is not possible to give responsible answers to these questions. With all the studies being made and supported by federal, state or foundation funds, it is unfortunate that none has been undertaken to elucidate the processes involved in career selection. This would be of immeasurable value to parents, schools, government and industry. And the results would be applicable to all fields. Most of us know of at least one youngster, who at the age of 10 - 12 knows precisely what he wants to study and the career he intends to follow. This is usually a youngster with one-sided maturity and highly polarised interests. Similarly we know of many more cases of young men, of more balanced maturity who, even at the mid-point of their undergraduate years, are still undecided as to what they want to do. These are often highly intelligent young men of broad interests and great capability.

The Career Decision

The author has often had qualms of conscience and serious misgivings about the educational system which tends to force these young men to make a decision. What is striking is that the decision-making process is neither wholly rational or conscious. In many conversations spanning many years a pattern seems to have emerged. The facts, real or imagined, which have been acquired are used in the logical argument given to arrive at a wish which is then elevated to the status of a logical conclusion. It is interesting to note that when new facts are introduced or old 'facts' are corrected, the adduced argument varies but the conclusion remains the same. Obviously the wish, which is the conclusion, has been arrived at by other than external, logical means. For all we know the decision to become a mining engineer may be nothing more than a wish to escape parental influence. Since mining offers the opportunity to work in some far-off place, it is not the young man's decision to remove himself from the parental orbit, it is the requirements of his profession.

One of the most popular misconceptions is that remuneration plays a vital role in the decision-making process. Perhaps, but in the writer's experience, he has never seen a case where this was even a minor, much less a major factor in the decision. It has been used as an *ad hoc, ex post facto* argument to validate a negative decision but even casual inquiry soon discloses the more potent and major reasons therefore. With students, who made their decision and who were graduating at a time when job opportunities were few and starting salaries were correspondingly low, remuneration

did play an important part in deciding some of these men to turn to other fields. Four of the writer's best students never practised their chosen professions of mining and mineral engineering but chose, upon graduation, to seek employment in other industrial fields. Remuneration was part of the reason for their defection; lack of foreseeable future opportunities was the more important reason.

It should be recognised by industry that improving starting salaries to make them competitive with those in other engineering fields may have little effect on the decision-making process, which takes place anywhere between the ages of 12 - 21; only a continuous history of competitive salaries may have much effect. In any event, immediate results must not be expected for the lag time is anywhere from 7 - 10 years. Such action can affect and minimise the defections from the ranks of the graduating mining engineers.

Professional Obsolescence

Of equal importance in minimising defections upon graduation and thereafter, is to alter the time-honoured methods of 'in-company training'. To start a mining engineer on a muck pile so that he may learn the difference between a left-handed and a right-handed shovel is certainly by now an archaic management practise. To deny to this engineer, until he has suffered professional obsolescence, the opportunity to apply in the company's interests, the new and exciting techniques to which he has been exposed in his training, is to frustrate his initiative and emasculate his creativeness. In the case of overseas and remote-area assignments, it should be made clear that this is not relegation to Siberia and that opportunities for advancement within the central corporate structure do exist.

Another misconception often voiced by industrial representatives is that mining curricula are outmoded and somehow inadequate. Whether valid or not, this criticism does serve the useful purpose of reminding educators that they must continuously strive to improve and update their offerings. In general, a study of these programmes over recent past history will disclose substantive changes resulting from the inclusion of recently developed information and techniques, e.g., rock mechanics, operations research methods, econometrics, chemical mining, computer methods, etc. The real danger is that, in trying to include these innovations, the more conventional requirements may be sacrificed. Another danger is that a graduate so trained may find that his industry does not and is not ready to use this more advanced technology and as a result disillusionment sets in. In any event, it is doubtful that either the tiro mining engineer or his counsellors use the mining curriculum as a pro or con argument in the selection of his profession — it may be used in selecting the school where he carries out his studies.

To use that irritating and overworked term of the ad men, the basic problem confronting the mining industry is its image. Unqualified though the writer is to offer constructive suggestions as to how this image may be improved, it is apparent that a massive effort will have to be mounted and sustained to correct this image. If successfully done, the beneficial consequences of attracting capable people into the industry will be overshadowed by the industry's improved relations with state and federal governments and above all, with the public at large.

Senator Moss. Now, Dr. Reid, we will be glad to hear you first.

**STATEMENT OF DR. ROLLAND R. REID, DEAN, COLLEGE OF MINES,
UNIVERSITY OF IDAHO**

Dr. REID. Thank you, it is a pleasure to appear here today and I bring you greetings from the State of Idaho. The United States is following a program of high consumption of minerals and energy. At the same time we have inadequately developed mineral reserves, few provisions for recycling of wastes, heavy pollution of our environment partly involving mineral extraction and processing, many unsafe and unhealthy mines, inadequate land use policy, and a severe shortage of trained personnel to work on the problems that grow out of the present circumstances.

Our domestic mineral production is already much less than national needs. Increasing foreign uses will result in diminishing foreign sources and the necessity to mine more of our supplies domestically. To meet our growing needs will require the full and efficient use of all our mineral lands. Mineral lands may be defined as any lands showing signs of mineralization. Idaho has 17 million acres of such lands. Such lands may contain no known mineral deposits of commercial value in the present economic climate, yet renewed search or changing needs may make them valuable at some future time. In order that such values may be utilized, mineral lands must be held open for continued mineral exploration (pollution-free, of course).

It is necessary to carry out geological, geophysical, and geochemical surveys to identify mineral lands—work that lies within the responsibility of the U.S. Geological Survey, the U.S. Bureau of Mines, and the various State surveys.

Much remains to be done. Placing large areas in special-use withdrawals prior to completion of such surveys seriously endangers future domestic mineral supply. In Idaho we see up to 6.5 million acres that are proposed for withdrawal at the present time. That is just one western State.

Mineral lands commonly have potential for other beneficial uses such as timber, grazing and recreation. Techniques to permit pollution-free utilization of these lands must be developed. Additionally, as it appears unlikely that all our mineral needs can be met even in this way, it will become necessary to recycle as much used mineral substance as possible.

The problems implicit in the foregoing program are almost without number. These problems must be solved if our national living standard is to remain at a high level. Many problems are of national scope and many, many more, of different sorts, are important in each of the States.

Most of these problems can be studied and solved most effectively at the State level. Large numbers of trained people will be necessary to do the work. When one sees the progress that has been made in such fields as agriculture, space research, and hydrology through proper funding, it is not hard to see that similar approaches will be successful in the mineral supply fields. Some of us had already begun to see this in 1967. I had hardly begun writing my Congressmen in 1967 in vain, Mr. Chairman.

Time does not permit a detailed recounting of even some of the most important problems. Therefore, I have taken the liberty to attach to this testimony a partial list of the kinds of mineral problems that lie within our perspectives at the University of Idaho. Additionally, data are presented that show the nature and level of operations both in teaching and research at one of the better western mining schools, the University of Idaho's College of Mines.

S. 635 contains the seeds of solution for many of our mineral-related problems, and it is a pleasure for that reason to give it my full endorsement.

If I might, I would like to add a couple of additional topics that have grown out of the earlier discussion.

Senator Moss. Yes; we will be glad to hear from you on that and we are pleased with this outline that you have furnished with your statement in a rather detailed document. It will be a great addition to our record and will be included in the record as part of your presentation.

Dr. REID. I did want to suggest consideration of the possibility in S. 635 to add a structure for some kind of a national research data coordinating center. I think the Water Research Institute has some comparable structure, if I recall correctly.

It is unwise to let research go on and duplicate. Perhaps it would be possible to get some saving through some such device and I don't think I have seen this language in the bill.

Senator Moss. I think we have something in there. That is certainly a most desirable thing so that there is a provision for annual reports publishing the research. There is something in there about a coordinating research center.

Senator ALLOTT. Yes; it is left to the Secretary, Mr. Chairman. It is in section 9.

Senator Moss. Yes; section 9. The Secretary of the Interior is charged with certain things and one of them is that he shall furnish such advice and assistance that will best promote the purposes of this act, participate in coordinating research initiated under this act by the institutes and encourage and assist in establishing and maintaining cooperation by and between the institute and between them and other research organizations and the Department of Interior and shall act as a central clearinghouse for the results of research conducted by the institutes. That is directly the point you are making.

Dr. REID. I stand corrected there. I did want to mention in Idaho we have labor enforcement and the board of regents has created 50 scholarships for out-of-State students for the out-of-State tuition and charges. These students can come from any other State in the country. We think this will help solve some of our problems.

Senator Moss. I am gratified to hear that too because of the problem we heard about in Colorado. You are attempting to meet that.

Dr. REID. Finally, I think looking toward regional cooperation, I just wanted to mention that in our corner of the country Washington has been closing down or has closed down its program for mining engineering and Oregon had their program closed out for some years.

We have taken preliminary discussions with those States to see if we might not function in Idaho as a regional center. We are studying the matter and I think that would be useful for people to know about and think about.

Senator Moss. Thank you. I am very glad to have you add those matters to your testimony, which was very good, and we appreciate your coming to give us the benefit of your view. We will now ask Dr. John Elliott of the Massachusetts Institute of Technology if he would proceed.

(The document by Mr. Reid referred to by Senator Moss follows:)

MARCH 25, 1971.

To: The National Academy of Engineering, Commission on Education and the U.S. Bureau of Mines.

From: Rolland R. Reid, Dean, College of Mines, University of Idaho.

Subject: (1) Future needs in education and research in material resource development; (2) current programs and plans at the University of Idaho; (3) prospects at the University of Idaho; and (4) staff, degrees, positions, research, and publications. Submitted for the panel meetings at Washington, D.C., March 25-26, 1971.

(1) General opportunities for future developments in educational and research programs in material resource development in the engineering schools. (There is no attempt to make an exhaustive analysis here. We have listed problems that loom large in our consciousness at the present time. No detailed discussion is presented as it would be too space consuming at this time.)

The United States is "suffering" from high mineral and energy consumption rates, inadequately developed mineral reserves, few provisions for recycling of wastes, heavy pollution of the environment partly involving mineral extraction and processing, many unsafe and unhealthy mines, inadequate land use policy, and a severe shortage of trained personnel to work on the problems that grow out of the present circumstances. The major tasks facing the nation's schools would seem to be to train the needed people for industry, government, and education; and to get as many of the necessary research programs underway as possible.

When one sees the progress that has been made in such fields as agriculture and space research through proper funding, it is not hard to see that similar approaches will be successful in the mineral sciences and engineering fields.

The topical list of problems that follows could, needless to say, be expanded upon indefinitely.

- a. Land use planning and classification.
- b. Improvement in mining law.
- c. Federal funding for teaching and research in mining schools, including scholarship support.
- d. Mined-land reclamation.
- e. Environmental research related to the mineral industries.
- f. Scrap and waste recycling (metals).
- g. Mineral exploration.
- h. Mineral economics.
- i. Health and safety problems in the mineral industries.
- j. Recruitment programs to draw more manpower into the mineral industries.
- k. Development of pollution-free mining and extraction methods.
- l. Methods to avoid unnecessary duplication of research activity in the several states and the government agencies.
- m. Environmental geology.
- n. Ceramic development.
- o. Hydrogeologic factors in sanitary landfill site selection.
- p. Ventilation of underground openings.
- q. Rapid excavation techniques.
- r. Underground mineral concentration systems.
- s. Deep mining techniques.
- t. New or improved techniques in mineral concentration and extraction.
- u. Pollution control and abatement in mining and extractive metallurgical processes.
- v. Program developments in materials science and engineering.
- w. Drain-well waste disposal techniques.
- x. Design of exploration programs in all phases of geological engineering.

- y. More emphasis on the applied side of geological engineering.
- z. Improve exploration and discovery.
- aa. Improve systems synthesis.
- bb. Study design of unit systems.
- cc. Materials handling.
- dd. Acid mine drainage.
- ee. Methane drainage and recovery.
- ff. Mine fire control.
- gg. Subsidence and caving control.
- hh. Fracture mechanics for mineral liberation.
- ii. Hydrofracturing.
- jj. Oil shale and tar sand exploration.
- kk. Ocean mining.
- ll. Leach mining.
- mm. Biological recovery and control of metal ions.
- nn. Comminution economics.
- oo. Support criteria.
- pp. Waste fill mechanics.
- qq. Rock burst control.
- rr. Rock penetration mechanics.
- ss. Dust control.
- tt. Hydro- and electro-metallurgical practices vs. pyrometallurgy.
- uu. Mine financing.
- vv. Taxation and assessment.
- ww. Man-machine interactions and problems.

The most critical underground problem is to unitize an operation in which least energy expenditure from deposit to metal is realized. A unit operation in which leaching of in-place ore at the orebody location producing a reasonably pure metal without ground contamination is to be desired. This requires identification of the deposit, recognition of rock mechanics involved, material transport, energy expenditure, and metallurgical processes including product use as one gross function.

(2) Current programs and plans at the University of Idaho—

- a. Degree programs currently available: Programs leading to the Ph.D. in Mining Engineering, Metallurgical Engineering, Geology (including Hydrogeology) and to the M.S. in Geological Engineering and Geography. All programs are fully accredited by all relevant accrediting groups.
- b. Cooperative exchange of graduate courses and library facilities with Washington State University (eight miles away).
- c. Current enrollment levels (27% increase from last year).

GRADUATES	
Geology.....	41
Geological Engineering.....	6
Geography.....	9
Hydrology.....	2
Metallurgical Engineering.....	2
Mining Engineering.....	2
	162
UNDERGRADUATES	
Geology.....	34
Geological Engineering.....	22
Geography.....	24
Metallurgical Engineering.....	11
Mining Engineering.....	15

² 106

¹ Including 12 foreign students.
² Including two foreign students.

Total—168

d. Service courses—1475 students are served annually in general courses in geology and geography.

e. UNDERGRADUATE SCHOLARSHIPS, 1971-72

Title of scholarship	Criteria			Amount and number available
	Year	Major	Other	
American Smelting & Refining Co. Hecla-Bunker Hill	Junior, senior Currently enrolled	Mining, metallurgy Mining engineer, geological engineer, metallurgical engineer.	Leadership; grades. Employees; sons and daughters of em- ployees. Come from Coeur d'Alene mining area (preference). Demonstrated need.	\$750 (1). Varies generally 1 or 2 mines students. \$1,800 (3 to 5).
A. E. Larson	.do.			
J. R. Simplot	.do.	Mining engineer.		\$1,300 (8 to 12).
W. W. Staley	.do.	Geology, geological engineer, mining en- gineer, metallurgical engineer.	Need; grades.	\$75 (1).
Out-of-State tuition	Entering freshmen and transfers.			50 at \$550 each (\$27,500).
Idaho Mining Association	Entering freshmen.			\$2,000 (4).
Idaho Mining Memorial	.do.		Demonstrate interest in minerals industries.	\$1,900 (3 to 4).
GRADUATE SCHOLARSHIPS				
A. H. Featherstone	Graduate			\$385 (2 to 3).

The University of Idaho also cooperates in a new W.I.C.H.E. program for exchange of students among the cooperating states that exempts out-of-state students from out-of-state tuition if the curriculum in mineral engineering that they wish to follow is not offered in their own state.

f. Graduate student support—the following kinds of support are currently held by graduate students in residence at the College of Mines—

- (1) Idaho Bureau of Mines and Geology Scholarships (4).
- (2) Teaching assistantships (8).
- (3) A.I.D. grants (7).
- (4) G.I. Bill (2).
- (5) Embassy Grant (1).
- (6) N.D.E.A. Fellowships (4).
- (7) NSF Science Faculty Fellowship (1).
- (8) NSF Traineeship (1).
- (9) NASA Research grant Fellowships (2).
- (10) Graduate Assistantship (2).
- (11) Irregular help (2).

Total supportees: 34.

g. Major Research Facilities, College of Mines, University of Idaho—

- (1) Mine-ventilation-research wind tunnel laboratory.
- (2) Electron microprobe laboratory.
- (3) Atomic absorption spectrophotometry laboratory.
- (4) Photogrammetry-aerial photography laboratory.
- (5) Paleobotany laboratory.
- (6) Mineragraphy laboratory.
- (7) Soils laboratory.
- (8) Rock Mechanics laboratory.
- (9) Aggregate analysis laboratory.
- (10) Paleontology laboratory.
- (11) Extractive metallurgy laboratory.

(3) Prospects at the University of Idaho for future development—

a. A program has been underway at the University for some years and is continuing to develop a regional center for mining education in the northwest, maintained while several neighboring schools have been closing their programs in the field of mining education.

b. The Bureau of Mining Research has been established several years ago to expedite work in contract research and it is coming along well.

c. Plans exist to enlarge the program in extractive metallurgy.

d. Plans exist to enlarge the research program in ventilation techniques for deep underground openings.

e. The program in rock mechanics is growing and will likely be expanded further.

f. A materials science curriculum has been developed and is at the Faculty Council level for approval.

g. The program in exploration geochemistry has been doing well and will likely expand.

h. The program in geological engineering is planned to be enlarged.

i. The work in water chemistry as it relates to mining pollution is at a high level now and is likely to grow still more.

j. The program in hydrogeology has recently been enlarged and is doing well.

k. Applied Geology—especially Economic Geology and Exploration Geology.

l. Continuing study of recruitment problems in mineral education is considered critical.

Realistic consideration of development of mineral resource education and research in the Northwest is dependent upon the source of funding. State funding requires that major emphasis be on State problems and needs, whereas industrial or federal funding can be used for more regional requirements.

In the State of Idaho, mineral resources do not include coal, oil, natural gas, and ocean mining. These are and will be important in the northwest, however. Resources such as metals, water, sand and gravel and phosphates are important both in Idaho and the northwest. Surface and underground operations are of equal importance in the region, but the underground operations take precedence in Idaho. Similarly, although less pronounced, the population density requires greater consideration in parts of the northwest for pollution; but, environmental and wilderness factors such as ecology, multiple use, conservation and mineral economics become of greater importance in Idaho where public land makes up the largest land area of the State.

If only State funds are involved, as at present, such important functions as coal mining and related health and safety programs, petroleum production, and

ocean mining cannot be considered except in a cursory manner. If outside funding is available, then coal mining must be considered and possibly other operations such as ocean mining if not available through other sources.

Development of mineral resource education and research is presently critical in either perspective. The College of Mines plans, with additional funding either State or Federal, to develop a first rate mineral resource education and research center from the present nucleus of approximately 10 staff members, a Ph. D. program, 70 years of past experience, and a growing research facility. The scope of the center will be appropriate to the demands and needs of both the State and the region.

Immediate developments must be centered around the underground and associated functions having inadequate development during the past decade. This includes increased basic education and research on such subjects as exploration and discovery of hidden minerals, removing and refining the metal or nonmetal and environmental control.

Mineral education must include technologic training of miners and technicians, education of junior engineers for technical and administrative operations and education of research personnel for basic research in all needed extractive processes. The personnel for teaching must be the first consideration. Personnel must somehow be developed for materials handling, ore discovery, operations research, metal extraction in place, fracture mechanics for support and metal release and environmental control for both health and safety and for pollution abatement. The College of Mines at Idaho can handle very few of these functions and conceivably 10 new staff members immediately plus yearly additions to the group for another decade is a minimum needed to develop the teaching capability for an adequate academic group. Innovation from the present stilted and rigid course structure is needed for exposure and integration of this knowledge; and, the four year and higher degrees must reflect these new disciplines. Probably much of the present accreditation requirements would have to be replaced by more useful course structuring in both technical and sociological fields.

The research development is progressing more satisfactorily than the academic. Purely academic research should be promoted on a lesser scale than applied research at the beginning. This is dictated not by the need but by the existence of competent personnel. Far too few people are even conversant with mining problems, and to dwell on long range basic research before becoming aware of the peculiar demands of the industry by working on short term applied problems would be unwise. Close cooperation with the well directed and established programs of the U.S. Bureau of Mines and some isolated industrial research would augment faculty capabilities and awareness. Both direct, cooperative and independent research activities should be encouraged. All faculty should have adequate time to conduct programs of some sort to maintain a current awareness of their fields.

In summary the College of Mines at Idaho needs to establish and/or strengthen the following capabilities in teaching.

- (1) Exploration and development—geologic, geochemical, geophysical.
- (2) Mining—materials handling underground, environmental surface and underground concepts, fracture mechanics applied to support and liberation, automation and mechanization, health and welfare fields, operations research, administration and economics.

- (3) Extraction—in place metal extraction, energy economics, wet extraction vs. pyrometallurgy, hydrologic control at depth.

Long range plans would call for development of coal mining and other mining activities. With funding these should be started at once but cannot be justified on a competitive basis with the above factors.

4. Staff: College of Mines and Idaho Bureau of Mines and Geology. (These are lumped, as the two agencies cooperate closely.)

(a) Department of Mining Engineering and Metallurgy—

BOBECK, GENE E., Ph.D. (University of Denver). Assistant Professor of Metallurgy.

CURRENT RESEARCH PROJECTS

1. "Cause and Prevention of Failure of Freshly Exposed Shale and Shale Material in Mine Openings." Funding: U.S. Bureau of Mines (Pending, 3 yrs., \$108,000).

2. "A Study of Zinc Extraction and Refining Processes and Their Improvement to Reduce or Eliminate the Discharge of Wastewater and Metals to the Environment." Funding: U.S. Bureau of Mines (in preparation, 3 yrs., \$30,000, with R. E. Williams).

3. "Oxidation of Metals and Alloys with Emphasis on Internal Oxidation." Funding: None formal. Study as time permits.

4. "Phase Stability in High-Temperature Alloys". Funding: None formal. Study as time permits.

RECENT PUBLICATIONS

Ph.D. Thesis, "A Study of the Precipitation of Sigma Phase in Iron—40% Chromium."

CHAN, SAMUEL S. M., Ph. D. (University of Idaho). Associate Professor of Mining Engineering.

CURRENT RESEARCH PROJECTS

1. "A Case Study of In-Situ Deformation Behavior for the Design of Ground Support System." Funding: U.S. Bureau of Mines, Spokane Mining Research Center (in progress, \$31,932).
2. "Effect of a Landfill on the Hydrogeologic Environment—A New Approach to an Old Problem." Funding: State of Idaho STAR Program (nearly completed, \$9,572, with R. E. Williams and A. T. Wallace).
3. "Comparative Study of Rock Stress and Property Measurement Equipment." Funding: Dept. of Defense APAR Program, first year program of \$72,851 was approved, now in negotiation, with J. R. Hoskins.

RECENT PUBLICATIONS

1. Waddell, G. G., T. J. Crocker, and S. S. M. Chan, 1971, Engineering Properties of Rocks and Rock Masses in the Deep Mines of the Coeur d'Alene Mining District: AIME-SME (Society of Mining Engineers) fall meeting, Seattle, Washington.
2. Chan, S. S. M., and T. J. Crocker, 1971, A Case Study of In-Situ Rock Deformation Behavior in the Silver Summit Mine, Coeur d'Alene Mining District: Fourth Canadian Symposium on Research in Tectonics and the Seventh Canadian Symposium on Rock Mechanics, Edmonton, Alberta, Canada, March (will present).
3. Chan, S. S. M., and T. O. Meyer, 1971, Over-Coring Stress Relief Experience in Belt Rocks: Ninth Annual Symposium on Engineering Geology and Soils Engineering, Boise, Idaho, April (will present).
4. Chan, S. S. M., 1971, Magnetic Susceptibility Study of Some Coeur d'Alene Ores and Rocks: (in preparation).
5. Chan, S. S. M., R. E. Williams, and A. M. Hemud, 1971, Application of Electrical Resistivity Methods to Investigate the Effect of a Landfill on the Hydrogeologic Environment, Moscow Area, Idaho: (in preparation).
6. Chan, S. S. M., and R. St. Clair, 1971, A Proposed Computer Method to Calculate Modulus of Elasticity of Rocks: (in preparation).
7. Chan, S. S. M., 1970, A Proposed Method to Obtain Actual Strength parameters of Mine Rocks and Rock Masses: The 2nd Congress of the International Society for Rock Mechanics, Beograd, Yugoslavia, Sept. 1970.
8. Chan, S. S. M., 1970, Deformation Behavior of Revett Quartzite under Uniaxial and Triaxial Compression: The 6th Canadian Rock Mechanics Symposium: Montreal, Quebec, Canada, May.
9. Chan, S. S. M., 1969, Suggested Guides for Exploration from Geochemical Investigation of Ore Veins at the Galena Mine Deposits, Shoshone County, Idaho: In the Proceedings of the International Geochemical Exploration Symposium, Quarterly of the Colorado School of Mines, Vol. 64, No. 1, p. 139-168.
10. Chan, S. S. M., 1966, Mineralogical and Geochemical Studies of the Vein Materials from the Galena Mine, Shoshone County, Idaho: Ph.D. dissertation, University of Idaho, Moscow, Idaho.
11. Chan, S. S. M., 1966, Geochemical Exploration of the Galena Mine: 72nd Annual Convention, Northwest Mining Association, Spokane, Washington, Dec. 3, 1966.
12. Chan, S. S. M., 1966, Geochemical and Microscopic Investigations of the Vein Materials from a Silver-Lead-Copper Deposit in Northern Idaho: 8th Annual Meeting, Idaho Academy of Science, Moscow, Idaho, April, 1966.

CLIFTON, DONALD F., Ph. D. (University of Utah). Professor of Metallurgy.

CURRENT RESEARCH PROJECTS

1. "Engineering Properties of Clay Interbeds in the Vicinity of Lewiston, Idaho." Funding: State of Idaho STAR Program, Project 52, with R. L. Schuster.
2. "The Response of Metastable and Equilibrium Phases in Rapidly Quenched Cu-Ag Alloys to Quenching Temperature." Funding: No funding, with student Bernal Femreite.

3. Preliminary work for a study of mineralogy, structure, and mechanical properties of mine roof shale. Funding: A proposal for funds has been submitted to the U.S. Bureau of Mines, with G. Bobeck.

RECENT PUBLICATIONS

1. Chamberlain, Courtney, Joseph Newton, and Donald F. Clifton, 1969, How Cyanidation can Treat Copper Ores: *Engr. and Mining J.*, Oct. issue.
2. Newton, Joseph, and Donald F. Clifton, 1970, Final Report—STAR Project 22, Leaching of Complex Copper-Silver Minerals, July.
3. Clifton, Donald F., 1960-1970, Metallurgy, in *Britannica Book of the Year: Encyclopaedia Britannica*, Chicago.

GREEN, WILLIAM R., M.S. (University of Nevada), (Ph. D. in progress at Washington State University). Assistant Professor of Mining Engineering (1/2). Mining Engineer, Idaho Bureau of Mines and Geology (1/2).

CURRENT RESEARCH PROJECTS

1. Geologic bibliography of Idaho through Jan. 1, 1969. Individual bibliographies for each 1:250,000 scale Army Map Service Quadrangle. Final corrections now being made; hopefully to be submitted for publication by Idaho Bureau of Mines and Geology in near future. Funding: Idaho Bureau of Mines and Geology.
2. Inventory of Idaho's mines and prospects, a collection and tabulation of raw data to be used in additional studies: (a) To determine regional groupings or trends of occurrences by commodity (now in progress); (b) to determine if statistically significant trends or groups indicate previously undefined geologic conditions (now in progress); (c) to determine if regional analysis can be utilized to indicate the increased likelihood of additional reserves, etc.; (d) to assist in evaluating wilderness, etc., withdrawals on other semiquantitative data than past production; (e) to determine the present state of knowledge concerning mines and mining districts in Idaho, thereby to assist in directing the future emphasis of Idaho Bureau of Mines and Geology and College of Mines resource investigations; (f) to determine the reserves or potential reserves of various mineral commodities in the state; (g) to determine the extent of mining and its impact (economic and environmental) on the state.

This inventory is now approximately 60% completed, with an anticipated final completion date of September 1, 1972. Funding: Idaho Bureau of Mines and Geology.

3. STAR proposal (to be submitted soon) in cooperation with College of Business and Idaho Mining Association; Study to determine economic impact of mining on a community or area. Funding: College of Mines.

RECENT PUBLICATIONS

1. Exploration Interest Around the State: Paper presented to Idaho Mining Association, August 1969. Abstracted in editorial in December 1969 issue of *Engineering Mining Journal*.
2. Testimony concerning the Sawtooth National Park Proposal (plus additional testimony concerning recommended changes in the federal mining law, submitted at the request of the congressional committee). Printed in U.S. House of Representatives, Committee on Interior and Insular Affairs, Sub-committee on National Parks and Recreation, Serial 91-7.

GREGORY, CEDRIC E., Ph.D. (University of Queensland). Professor of Mining Engineering (Ventilation).

CURRENT RESEARCH PROJECTS

1. "Model Studies to Determine the Optimum Practical Arrangement of Timberwork to Ensure Minimum Resistance Values for Rectangular Shafts (by wind tunnel analysis)." Funding: Proposal has been made to U.S. Bureau of Mines.
2. "The Reduction of High Mine Resistance Values in Underground Metal Mines." Funding: Proposal being submitted to U.S. Bureau of Mines.
3. "Heat Flow in Mine Workings." Funding: Proposal being submitted to U.S. Bureau of Mines.
4. "Working Face Ventilation." Funding: Proposal being submitted to U.S. Bureau of Mines.

5. "A Study of Aerodynamic Parameters for Rectangular Shaft Design." Research under way for paper to be presented at VII International Mining Congress, Bucharest, 1972. Funding: No funding as yet.

RECENT PUBLICATIONS

1. New States Necessary for Mineral Development: Australian Mining, Feb., 1966.
 2. Aerodynamic Aspects of Mine Shaft Design: Ph. D. Thesis, U. of Queensland, 1966.
 3. The Shielding Factor as an Important Parameter in Mine Shaft Design: Trans. Inst. Min. Metall., (Sect. A) Vol. 75, April, 1966.
 4. The Possible Use of Interference Plates for Reduction of Shaft Resistance: J. Mine Vent., Soc. S. Afr., July, 1966.
 5. An Appraisal of the Bromilow Formula: Trans. Instn. Min. Engrs., Aug., 1966.
 6. The Importance of Aerodynamic Aspects in the Design of Mine Shafts: Trans. A.I.M.E., Vol. 238, 1967.
 7. Some Aerodynamic Effects of Bratticing in Shafts: Proceedings of Fifth International Mining Congress, Moscow, U.S.S.R., July, 1967.
 8. Ventilation Economics: Mining Congress Journal, March, 1970.
- HOSKINS, JOHN R., Ph. D. (University of Utah). Professor of Mining Engineering and Head, Department of Mining Engineering and Metallurgy.

CURRENT RESEARCH PROJECTS

1. Hecla Mining Co. Grant—Ventilation, \$16,000, C. E. Gregory, R. R. Reid, J. R. Hoskins. 6/6/68.
2. Large Grant, University of Idaho Tunnel Ventilation Model, \$6,000, J. R. Hoskins, C. E. Gregory. 7/31/68.
3. Large Grant, Testing Machine, College of Engineering and College of Mines, \$2,800. 10/68.
4. Mine Ventilation Problems Caused by Mechanization—STAR 60:26, \$3,800, J. R. Hoskins, C. E. Gregory. 11/12/68.
5. Equipment Purchase, Rock Drills, \$3,500, J. R. Hoskins, R. L. Schuster, G. A. Williams. 4/17/69.
6. Extension of STAR 60:26, \$1,925, J. R. Hoskins and C. E. Gregory. 5/6/69.
7. Occupational Choice—Research Grant—AMAX, \$1,000, Department of Mining and Metallurgy. 11/69.
8. Graduate Supplemental Awards, \$1,000, Faculty Graduate Scholarship, J. R. Hoskins. 2/23/70.
9. Development of Improved Ventilation Technology for Non-Coal Mines, U.S. Bureau of Mines Grant, \$31,953, J.R. Hoskins and C. E. Gregory. 4/16/70.
10. Temperature Balance in New Mine Openings, STAR 41:055, \$2,880, J. R. Hoskins and C. E. Gregory. 4/22/70.
11. Occupational Choice and Mineral Engineering in Idaho, U.S. Bureau of Mines Grant, \$23,289, J. R. Hoskins and E. Thomas Cain, II. 6/1/70.
12. A Case Study of In-Situ Rock Deformation Behavior for the Design of Ground Support System, U.S. Bureau of Mines, \$29,320, J. R. Hoskins and Samuel S. M. Chan. 7/1/70.
13. Occupational Choice—Research Grant—AMAX, \$1,000, Department of Mines and Metallurgy. 11/70.

RECENT PUBLICATIONS

1. Hoskins, J. R., 1965, Discussion on Design and Construction of a Facility for Research on the Inelastic Behavior of Geologic Materials: ASTM Conference, Seattle, 1965.
2. Hoskins, J. R., and Frank G. Horino, 1968, Effect of End Conditions in Determining Compressive Strength of Rock Samples: U.S. Bureau of Mines Rept. of Inv. 7171, 22 p.
3. Horino, Frank G., J. R. Hoskins, and Merlyn L. Ellickson, 1969, A Method of Measuring Surface Texture of Rock: U.S. Bureau of Mines, Rept. of Inv. 7095, 14 p.
4. Hoskins, John R., and Frank G. Horino, 1969, Influence of Spherical Head Size and Specimen Diameters on the Uniaxial Compressive Strength of Rocks: U.S. Bur. of Mines, Rept. of Inv. 7234, 16 p.

5. Hoskins, J. R., 1969, The Mineral Industry—Which Image?: Pacific Northwest Metals & Minerals Conference, Apr. 19, 1969, Coeur d'Alene, Idaho. Published by Northwest Mining News in 4 issues dated June 20, 27, July 3, 11, 1969.

6. Hoskins, J. R., 1969, Let's Look at Our "Image": Minerals Processing, Vol. 10, No. 11, Nov. 1969, p. 10-11, 21-23, 31.

7. Hoskins, J. R., and E. Thomas Cain, II, 1970, Idaho Student Survey Shows Mining is Still "Tuned Out" in High Schools: Engineering and Mining Journal, Vol. 171, No. 6, June, 1970, p. 113, 266.

8. Hoskins, J. R., 1970, Lead Industry Wastes; WASTES, C. L. Manfell, ed., John Wiley (in process 1970).

9. Haffner, R. L., and J. R. Hoskins, 1970, Timbered Stopes: Mining Engineers Handbook, AIME (in process 1970).

10. Hoskins, J. R., 1970, Property Testing Procedure for the Chemical Stabilization Program: Internal Report, U.S. Bureau of Mines, 1970, 102 p.

NEWTON, JOSEPH, M.S. (University of Idaho). Professor of Metallurgy, Assistant Dean, College of Mines.

CURRENT RESEARCH PROJECT

Leaching of tetrahedrite (with Curtis Carey).

RECENT PUBLICATION

How Cyanidation can Treat Copper Ores: Engineering and Mining Journal, October, 1969 (with C. Chamberlain and D. F. Clifton).

(b) Department of Geology—

HALL, WILLIAM B., Ph.D. (University of Wyoming). Professor of Geology.

CURRENT RESEARCH PROJECTS

1. Stereo color air oblique photography for geological reconnaissance. Funding: Partly personal, partly by Idaho Bureau of Mines and Geology.

2. Application of stereo color air oblique photography to 4 selected test areas for comparative evaluation of geological mapping techniques. Funding: U.S. Geological Survey.

3. Comparative study of normal color with infrared color air photography for potential in evaluating or delineating ground-water seepage areas in cultivated fields. Funding: Partly personal, partly WRRRI (for film partly City of Moscow).

4. Glacial deposits and quaternary history of the Upper Gallatin-Madison-Henrys Lake area, Montana and Idaho. Funding: Idaho Bureau of Mines and Geology in past summers, personal funds this summer.

RECENT PUBLICATIONS

1. Abstract—Relative significance of geologic factors in interstate highway location selection: Geol. Soc. of Amer., 1965.

2. Production and interpretation of three-dimensional color air oblique photographs for geological reconnaissance: Geol. Soc. America Program for 1966 Ann. Mtg. (abstract), p. 83, 1966.

3. Photogeologic analysis of the Selway-Bitterroot area, in Greenwood, W. W., and Morrison, D. A., 1967, Reconnaissance geology of the Selway-Bitterroot Wilderness Area: Idaho Bureau of Mines and Geology Inf. Circ. 18, p. 12-14, 1 plate, 1967.

4. Methods for increasing efficiency of geologic reconnaissance: U.S. Geological Survey Prof. Paper (in preparation).

5. Applications of stereo color air oblique photos for geology, forestry and ecology: Photogrammetric Engineering (in preparation).

JONES, ROBERT W., Ph. D. (University of Washington). Associate Professor of Geology.

CURRENT RESEARCH PROJECTS

1. Moscow Basin Ground-Water Studies. Funding: Water Resources Research Institute, U.S. Department of Interior, and Idaho Bureau of Mines and Geology.

2. Twin Falls South Side Tract Ground-Water Studies. Funding: Idaho Bureau of Mines and Geology.

3. Geology of a Part of East-Central Idaho. Funding: Idaho Bureau of Mines and Geology.

RECENT PUBLICATIONS

1. Pumping tests as a geologic tool: Proceedings of 2nd Annual Idaho Engineering Geology and Soils Engineering Symposium, p. 59-68. Junior author with Daniel Sokol. 1964

2. Feasibility of artificial recharge of a small ground-water basin by utilizing seasonal runoff from intermittent streams: Proceedings of the 6th Annual Engineering Geology and Soils Engineering Symposium, p. 258-282. Senior author with S. H. Ross and R. E. Williams. Read at the Symposium in Boise, April 17-19, 1968.

3. Moscow basin ground water problem: "How long will the water last?": Proceedings of the 7th Annual Engineering Geology and Soils Engineering Symposium, p. 62-82. Senior author with S. H. Ross. Read at the Symposium in Moscow, April 9-11, 1969.

4. Comparison of Columbia River Basalts and Snake River Basalts: Proceedings of the N.W. Sci. Soc. Symp. on Columbia River Basalt. Read at the Symposium at Cheney, March 21-22, 1969. Abs. publ. in Northwest Science, Vol. 32, No. 1, p. 37. Full paper should be published by June.

6. Records of water-level measurements in observation wells, Twin Falls South Side Tract, Idaho, 1909-1947: Idaho Bureau of Mines and Geology Open File Report.

POWELL, JAMES D., Ph. D. (University of Texas at Austin). Associate Professor of Geology.

CURRENT RESEARCH PROJECTS

1. Upper Cretaceous strata in North Texas. (Biostratigraphy, palenotology, sedimentary petrology.) Funding: Past funding by Bureau of Economic Geology, the University of Texas, Austin, Texas.

2. General stratigraphy of Late Cretaceous rocks in the Western Interior, U.S. and northern Mexico.

RECENT PUBLICATIONS

1. Mammitine ammonites in Texas Cretaceous: Texas Journal of Science, Vol. XIX, p. 311-322, November, 1967.

2. Woodbine-Eagle Ford transition, Tarrant Member: *in* Field Trip Guidebook 2nd Ann. Mtg., South-Central Sec., Geol. Soc. America, C. F. Dodge, Editor, 1968.

3. Cenomanian-Turonian Facies across the Raton Basin: The Mountain Geologist, Vol. 6, p. 93-118, July 1969. (With E. G. Kauffman and D. E. Hattin).

4. Early Upper Cretaceous faunal zones southwest of the Diablo-Coahuila Platform: *in* Geology of the southern Quitman Mtns. area: Field Trip Guidebook, Permian Basin Sect., S. E. P. M., p. 96-99, April, 1970.

5. Field Trip Guidebook for the First Inter-American Micropaleontological Colloquium, July, 1970, J. Dan Powell, Editor, 125 p.

REID, ROLLAND R., Ph.D (University of Washington). Professor of Geology, Dean, College of Mines, and Director, Idaho Bureau of Mines and Geology.

CURRENT RESEARCH PROJECTS

1. Multiple Precambrian metamorphism of the Beltian rocks of northern Idaho. Funding: Partial support by NSF, \$10,900, with W. R. Greenwood and G. L. Nord. Publication in preparation.

2. Geologic history of the Clearwater Orogenic Zone of Northern Idaho. Funding: Partial support by NASA, \$24,328. Inputs from 17 graduate theses and 14 years of my own work, Age-dating currently in progress (20 zircon ages, 10 K-A ages, and 10 Rb-Sr ages).

3. Multiple Precambrian metamorphism in the North Snowy Block, Beartooth Range, Montana. Funding: Partial support at Montana State University by NSF, \$60,000. Collaboration with Professor W. J. McMannis of Montana State University and Professor John C. Palmquist of Lawrence University. Publication in preparation.

4. Currently supervising 8 Ph. D. theses and 1 M.S. thesis.

RECENT PUBLICATIONS

1. Reid, R. R., and W. R. Greenwood, 1967, Mafic intrusive rocks in the St. Joe region, Idaho (abs.): Northwest Scientific Association, April, at Pullman, Washington.

2. Reid, R. R., W. R. Greenwood, G. L. Nord, and J. D. Cook, 1967, Geology of the St. Joe area, Idaho: Part I, Structural Geology (abs.): Geol. Soc. America, Rocky Mountain Section, Program, 1967 Annual Meeting, p. 56.

3. Reid, R. R., and W. R. Greenwood, 1967, Geology of the St. Joe area, Idaho: Part II, Metamorphic crystallization (abs.): Geol. Soc. America, Rocky Mountain Section, Program, 1967 Annual Meeting, p. 56.

4. Reid, R. R., and W. R. Greenwood, 1968, Multiple deformation and associated progressive polymetamorphism in the Beltian rocks north of the Idaho batholith, U.S.A.: Proceedings, XXIII International Geological Congress, Vol. 4, p. 75-87.

5. Greenwood, W. R., and R. R. Reid, 1969, The Columbia Arc: New evidence for pre-Tertiary rotation: Geol. Soc. America, Bull., Vol. 80, p. 1797-1800.

6. Reid, R. R., 1969, Scotsford's metasomatic augen gneiss: an additional working hypothesis: Geol. Soc. America, Bull., Vol. 80, p. 2653-2654.

7. Reid, R. R., W. R. Greenwood, and D. A. Morrison, 1970, Precambrian metamorphism of the Belt Supergroup in Idaho: Geol. Soc. America, Bull., Vol. 81, p. 915-918.

SIEMS, PETER L., D.Sc. (Colorado School of Mines). Associate Professor of Geology.

CURRENT RESEARCH PROJECTS AND RECENT PUBLICATIONS

Project title: Geology and geochemistry of the Hoodoo Mining District, Latah Co., Idaho.

Funding: Partly supported by the Idaho Bureau of Mines and Geology.

Publications: McNeill, A. R., and P. L. Siems, 1971, The Mizpah Mine: a metamorphosed, metahydrothermal copper deposit in the Belt Supergroup of northern Idaho (abs.): in Abstracts with programs, Geol. Soc. American, Rocky Mountain Section Vol. 3, No. 4.

Project title: Metamorphism of sulfide ore bodies.

Funding:—

Publications: Siems, P. L., 1969, Discussion of regional metamorphism of the Paleozoic geosynclinal sulfide ore deposits of Norway and classification and genesis of some massive sulfide deposits in Norway: Trans. Inst. Min. Metall. (London), Vol. 78, p. B95-B96.

Project title: Silver content in tetrahedrite-group minerals.

Funding: STAR 36

Publications: None.

Project title: Geochemical exploration for copper in the State of Bahia, Brazil.

Funding: Brazilian Government funds.

Publications: Siems, P. L., Brim, R. J. P., Maltoso, S. Q., and Sieffermann, G., 19 , Secondary dispersion of copper in a tropical environment near Maragojipe, State of Bahia, Brazil: submitted to AIME for Seattle meeting Fall 1971, for publication in Trans. AIME.

Project title: Geochemical techniques in exploration for silver in the Coeur d'Alene region, Idaho.

Funding: STAR 23.

Publications:

Brim, R. J. P., 1968, Geochemical exploration studies in the Lakeview mining district, Bonner County, Idaho: M.S. Thesis, Univ. Idaho.

Chauhan, E. H., 1968, Application of emission spectrorgraphic analysis of soils: in geochemical exploration of the Lakeview district, Bonner County, Idaho: M.S. Thesis, Univ. Idaho.

Juras, D. S., and Siems, P. L., 1969, Use of the citrate-extractable total heavy metals test in prospecting for silver veins, Coeur d'Alene district, Idaho (abs.): Geol. Soc. America Abstracts with program for 1969, part 5, p. 38.

Lee, Tien-Chang, 1969, Application of atomic absorption spectroscopy to geochemical exploration in northern Idaho: M.S. Thesis, Univ. Idaho.

Siems, P. L., and J. H. Galbraith, 1970, Application of statistics and atomic absorption spectrophotometry in geochemical exploration of the Lakeview Mining District, Bonner County, Idaho: in preparation.

Siems, P. L., 1970, Influence of Recent volcanic ash falls on geochemical soil surveys: in preparation.

Project title: Geology of the Priest Lake area, Bonner County, Idaho

Funding: Idaho Bureau of Mines and Geology (in part)

Publications: None

Project title: Geology of the Boulder Creek area, Boundary Co., Idaho

Funding: Idaho Bureau of Mines and Geology (in part)

Publications: None

Project title: Problems of ore deposition, Coeur d'Alene mining district, Idaho

Funding: Private funds—Industry (in part)

Publications: Private reports

Project title: Geochemistry of the Belt Supergroup in the Coeur d'Alene mining district

Funding: Private funds—industry

Publications: None

Project title: Hydrothermal alteration of volcanic rocks related to disseminated molybdenum-cooper mineralization, Capoose Lake area, British Columbia

Funding: Private funds—industry

Publications: None

SMILEY, CHARLES J., Ph.D. (University of California at Berkeley), Professor of Geology.

CURRENT RESEARCH PROJECTS

1. Biostratigraphy and correlation of nonmarine Cretaceous rocks across the North Slope of Alaska.
2. Funding for past Arctic field work by Arctic Institute of North America and the Office of Naval Research.
3. Funding for laboratory work currently being conducted on collected Alaskan material by Idaho Bureau of Mines and Geology; also, various types of laboratory services, information exchange, personal research funds, and other cooperative efforts with such petroleum companies as Humble, Mobile, Atlantic Richfield, Union of California.
4. Fulbright Grant, Malaysia; Cretaceous plant biostratigraphy of Malaysia (1968-69).

RECENT PUBLICATIONS

- 1966, Cretaceous Floras from Kuk River Area: G.S.A. Bull, 77, p. 1-14.
- 1967, Paleoclimatic Interpretations of Some Mesozoic Floral Sequences: AAPG Bull. 51, p. 849-863.
- 1969a, Cretaceous Floras of Chandler-Colville Region: AAPG Bull, 53, p. 482-502.
- 1969b, Floral Zones and Correlations of Cretaceous Kukpowruk and Corwin Formations, Northwestern Alaska: AAPG Bull. 53, p. 2079-2093.
- 1970a, Later Mesozoic Flora from Maran, Pahang, West Malaysia, Part I: Geologic Considerations: Geol. Soc. Malaysia Bull. 3, p. 77-88.
- 1970b, Later Mesozoic Flora from Maran, Pahang, West Malaysia, Part II: Taxonomic Considerations: Geol. Soc. Malaysia Bull. 3, p. 89-113.
- 1971, Cretaceous Floral Sequences in the Alaskan Arctic: Paper read at 2nd International Symposium on Arctic Geology, Feb. 1-4, 1971, San Francisco. *Abstract:* AAPG Bull. 54, No. 12.
- 1971(?), Plant Megafossil Sequences, North Slope Cretaceous: Invited paper read at Amer. Assoc. Stratig. Palnologists Ann. Mtg., Toronto, Oct. 15, 1970. Requested manuscript (about 30 typed pages and 5 figures) completed and sent for review and eventual publication in Proceedings Volume of AASP.
- Several titles and abstracts of papers read at professional meetings in United States and Malaysia.
- WILLIAMS, GEORGE A., Ph.D. (University of Arizona). Professor of Geology, Head, Department of Geology.

CURRENT RESEARCH PROJECTS

1. Geology of the Mineral Quadrangle. Funding: Idaho Bureau of Mines and Geology.
2. Geology and Structure in the Coeur d'Alene Mining District, Idaho.
3. Sanitary Landfill Studies at Moscow.
4. Water Levels on the Snake Plain.
5. Color Photography used as an Exploration Tool in the Search for Uranium in Wyoming.

RECENT PUBLICATIONS

1. 1964, Parts of Mineral and Water Resources of Idaho: Idaho Bureau of Mines and Geology Special Report No. 1, prepared for the U.S. Senate, November 1964.

2. 1967, The Phosphate Industry in Idaho: Special publication, Montana Bureau of Mines.

3. 1967, Geology of Southeastern Idaho Central Phosphate Region: Anatomy of the Western Phosphate Field, Fifteenth Annual Field Conference. Co-author: H. J. Holstein, Jr.

4. 1968, Thorium Mineral Reserves of Idaho: Idaho Nuclear Energy Commission.

WILLIAMS, ROY E., Ph. D. (University of Illinois), Professor of Geology.

CURRENT RESEARCH PROJECTS

1. Flow of water beneath an irrigated plot (with Gordon R. Stephenson, A.R.S., and David W. Allman).

2. Factors relative to ground-water recharge in Idaho (with Douglas D. Eier, Richard Wallace, and Omar Shadid).

3. Analysis of an aquatic environment receiving industrial and domestic wastes (with Alfred T. Wallace, College of Engineering, and LeRoy Mink).

4. Effects of urbanization on the hydrology of the Boise Basin (with Norman Dion, U.S. Geological Survey, and Omar Juedah).

5. Effect of a landfill on hydrogeologic environment (with Alfred T. Wallace, College of Engineering, and Harold Seitz).

6. Effect of drain wells on ground-water quality in the Snake River Plain (with Alfred T. Wallace and Don Abeggan, College of Engineering).

7. The role of tailings ponds in reducing the discharge of heavy metal ions to the environment (with Alfred T. Wallace, College of Engineering, LeRoy Mink, Carl Ellsworth, and James Galbraith).

RECENT PUBLICATIONS

1. Williams, R. E., and R. N. Farvolden, 1967, The Influence of Joints on the Movement of Ground Water Through Glacial Till: *Journal of Hydrology*, Vol. V, No. 2, p. 163-171.

2. Williams, R. E., 1967, The Influence of Ground-Water Flow Systems on Pavement Stability in Highway Cuts: *Ground Water Journal*, Vol. V, No. 4, Paper also presented at Regional Meeting of G.S.A. at Bloomington, Indiana, April, 1967, Abstract published in Special Paper 115, G.S.A., p. 401.

3. Williams, R. E., 1967, Gravity Ground-Water Flow Systems and Related Frost Heaving in Mountain Valleys: *Proceedings of the Fifth Annual Engineering Geology and Soils Engineering Symposium*, Idaho State Univ., Univ. of Idaho, and Idaho Dept. of Highways, Pocatello, Idaho, April 12-14.

4. Williams, R. E., 1968, Gravity Ground-Water Flow Systems and Related Frost Heaving in Cold Mountain Valleys: *Journal of Hydrology*, Vol. VI, No. 2, p. 183-193 (revision of publication above).

5. Williams, R. E., and P. Fowler, 1967, An Empirical Analysis of Drainage Network Adjustment of Precipitation Input: *Trans. Amer. Geoph. Union*, Vol. XXXXVIII, No. 1, March, p. 97 (abstract).

6. Fowler, P., and R. E. Williams, 1968, An Experimental Design for Analysis of Drainage Basin Adjustment: *Trans. Amer. Geoph. Union*, Vol. 49, No. 2, June, p. 523 (abstract).

7. Williams, R. E. 1967, The Effect of Geometry, Phreatophyte Density and Distribution of Precipitation on Ground-Water Flow near Small Closed Basins in Northeastern Illinois: Paper presented at 1967 national meeting of G.S.A., New Orleans; *Special Paper 115*, G.S.A., p. 238-239 (abstract).

8. Williams, R. E., and A. T. Wallace, 1970, Hydrogeologic Aspects of the Selection of Refuse Disposal Sites in Idaho: Idaho Bureau of Mines and Geology, Moscow, Idaho, and Idaho Dept. of Health, Pamphlet 145, 31 p.

9. Abegglen, D. E., A. T. Wallace, and R. E. Williams, 1970, The Effects of Drain Wells on the Ground-Water Quality of the Snake River Plain: Idaho Bureau of Mines and Geology Pamphlet 148, 51 p.

10. Williams, R. E., and P. M. Fowler, 1968, Geomorphic Parameters as Predictive Devices in Hydrogeology: Presented at Northwest Regional Meeting of G.S.A., (abstract).

11. Williams, R. E., 1968, Flow of Ground-Water Near Small Closed Basins in Glacial Till: *Water Resources Research*, Vol. 4, No. 4, p. 777-785.

12. Williams, R. E., 1968, Ground-Water Flow Systems and the Origin of Evaporite Deposits: Idaho Bureau of Mines and Geology Pamphlet No. 141, 15 p.

13. Williams, R. E., 1968, Graduate Studies in Hydrology and Hydrogeology at the University of Idaho: *Ground Water Journal*, Vol. VI, No. 3.

14. Williams, R. E., 1969, Low Flow Transport of Algae Nutrients: Jour. Amer. Wat. Works Assoc., Vol. 61, No. 10, p. 525-532.

15. Jones, R. W., S. H. Ross, and R. E. Williams, 1968, Feasibility of Artificial Recharge of a Small Ground-Water Basin by Utilizing Seasonal Runoff from Intermittent Streams: Proceedings of 6th Annual Idaho Engineering Geology and Soil Engineering Symposium, sponsored by Univ. of Idaho, Idaho State Univ., and Idaho Dept. of Highways, Boise, April 17-19.

16. Williams, R. E., and P. Fowler, 1969, A Preliminary Report on An Empirical Analysis of Drainage Network Adjustment to Precipitation Input: Journal of Hydrology, Vol. 8, No. 2, p. 227-238.

17. Williams, R. E., and D. W. Allman, 1969, Factors Affecting Infiltration and Recharge in a Loess Covered Basin: Journal of Hydrology, Vol. VIII, No. 3, p. 265-281.

18. Williams, R. E., 1968, Comments on Water Transfers and Related Problems in Urban Areas: Ground Water Journal, Vol. 6, No. 6.

19. Williams, R. E., D. D. Eier, and A. T. Wallace, 1969, Feasibility of Reuse of Treated Waste Water for Irrigation, Fertilization, and Ground-Water Recharge in Idaho: Idaho Bureau of Mines and Geology Pamphlet 143, 110 p.

20. Williams, R. E., Ground-Water Flow Systems and the Accumulation of Evaporite Minerals: A.A.P.G. Bull., Vol. 54, No. 7, p. 1290-1295.

21. Allman, D. W., R. E. Williams, and G. P. Stephenson, 1969, Design and Operation of an Inexpensive, Sensitive Piezometer with Short Timelag: Ground Water Journal, Vol. 7, No. 6, p. 14-16. (Paper presented at 1969 annual national meeting of National Water Well Association, St. Louis, Mo.)

22. Williams, R. E., 1970, Applicability of Mathematical Models of Ground-Water Flow Systems to Hydrogeochemical Exploration: Idaho Bureau of Mines and Geology Pamphlet 144, 13 p.

23. Kealy, D. and R. E. Williams, 1970, Mathematical Models of Ground-Water Flow as an Aid for Predicting Slope Stability in Tailings Pond Embankments: Proceedings, 8th Annual Idaho Engr. Geol. and Soils Engr. Symp., Idaho State Univ., Pocatello, p. 21-36.

24. Mink, L. L., R. E. Williams, and A. T. Wallace, 1970, Analysis of an Aquatic Environment Receiving Industrial and Domestic Wastes: Proceedings, 4th Annual Conference on Trace Substances in Environmental Health, Univ. of Missouri, Columbia, Missouri, June, 1970 (paper presented at conference).

25. Kealy, D., and R. E. Williams, 1971, Flow through a Tailings Pond Embankment: W.R.R. (in press). Paper was also presented at 1970 National Meeting of G.S.A.; abstract to be published in G.S.A. Special Papers Volume.

26. Mink, L. L., R. E. Williams, and A. T. Wallace, 1971, Effect of Industrial and Domestic Wastes on the Water Quality of the Coeur d'Alene Basin: Idaho Bureau of Mines and Geology Pamphlet 149 (in press).

ALLMAN, DAVID W., M.S. (University of Illinois). (Ph.D. (Hydrogeology) nearly complete at University of Idaho.) Hydrogeologist, Idaho Bureau of Mines and Geology; Assistant Professor of Geology (1/4-time), University of Idaho.

CURRENT RESEARCH PROJECT

Ground-Water Flow System Under an Irrigated Alfalfa Field Funding: Agricultural Research Service and Idaho Bureau of Mines and Geology.

RECENT PUBLICATIONS

1. Factors affecting infiltration and recharge in a loess covered basin: J. of Hydrol, Vol. 8, 1969, p. 265-281. (with R. E. Williams)

2. Design and operation of an inexpensive sensitive piezometer with short timelag: Ground Water, Vol. 7, No. 6, 1969. (with R. E. Williams and G. R. Stephenson.)

BISHOP, DONALD T., M.S. (University of Wyoming). (Ph.D. (Geology) nearly complete at University of Idaho.) Geologist, Idaho Bureau of Mines and Geology; Assistant Professor of Geology (1/4-time), University of Idaho.

CURRENT RESEARCH PROJECTS

1. a. Trace element distribution in Precambrian and Laramide galenas. b. Geochemistry of the lower and middle Prichard formation contact zone and associated mineralization. c. Petrology and geochemistry of Purcell sills and associated ore deposits.

Analytical work by neutron activation analysis supported by a grant from the Idaho State Department of Higher Education.

2. Structural geology and petrology of polymetamorphic rocks of the Belt Supergroup and their relation to Precambrian and younger mineralization.
3. Reconnaissance geology of Boundary County, Idaho.
4. Stratigraphy and depositional environment of the lower Belt Supergroup in Boundary County, Idaho.

RECENT PUBLICATIONS

1. 1967, The Application of Geology to the Study of Ground Water: Proceedings of the Second Idaho State Water Conference, University of Idaho, Moscow, Idaho.
2. 1969, Stratigraphy and Distribution of Basalt, Benewah County, Idaho: Idaho Bureau of Mines and Geology Pamphlet 140.
3. 1969, Geology and Mineral Resources of Boundary County, Idaho: Bureau of Business and Economic Research, University of Idaho, Moscow, Idaho.
4. 1970, Turbidites and Depositional Features of the Lower Belt-Purcell Supergroup: Geological Society of America Annual Meeting, Milwaukee, Wisconsin. Abstract and paper presented.

BOND, JOHN G., Ph. D. (University of Washington). Senior geologist, Idaho Bureau of Mines and Geology; Professor of Geology (¼-time), University of Idaho.

CURRENT RESEARCH PROJECTS

1. General Geology and Highway Alignment Considerations in the Little Salmon Canyon (with P. Breerer). Idaho Department of Highways assistance.
2. Road Metal and Aggregate Source Problems in Columbia River Basalt (with Ron Larson).
3. Evolution of Columbia Plateau.
4. Geologic Map of Idaho (revised ed.).
5. Geology and Highway Alignment Considerations in the Nezperce-Orofino-Kamiah Area, Idaho (with M. Shea). Idaho Department of Highways assistance. (Completed)
6. The Eastern Columbia Plateau—A Study in Isostatic Response and Post Extrusion Adjustments: Paper presented at 1969 I.A.V.C.E.I. Symposium, Oxford.

KNOWLES, CHARLES R., M.S. (University of Chicago). Electron Microprobe Analyst, Idaho Bureau of Mines and Geology, Assistant Professor of Geochemistry (¼-time), University of Idaho.

CURRENT RESEARCH PROJECTS

Charles Knowles has worked to get the electron microprobe in operation as an analytical tool for routine analysis of rock and ore forming minerals. Having developed a procedure on the probe, he taught a portion of the Geochemistry class along with Professor M. Wai of the Chemistry Department.

American Smelting and Refining Company was interested in the possibility of developing a device for underground ore grade quality control and asked the Idaho Bureau of Mines and Geology for help. Knowles and Donald Bishop borrowed a lithium drifted silicon detector from Keveex Corp. and a multichannel analyser from Nuclear Data Inc. and found that they could detect less than 10 oz/ton of silver in the galena mine ore.

The Bunker Hill Smelter asked Knowles to help solve a problem they were having in their zinc and lead concentration operation. The zinc concentrate contained too much silver and lead. They wanted to know in what form the silver was in and was there some way to decrease the silver and lead in the concentrate. He found by using the microprobe that the sphalerite contained small inclusions of argentiferous galena. The solution to the problem was to use a middlings or crush the sample finer.

Presently he is studying the relationship of silver to tetrahedrite in the Coeur d'Alene ores, teaching a graduate class of research methods making use of the electron microprobe, working jointly with Dr. Y. Rosen of Washington State University studying foraminifera chemistry, working Dr. C. M. Wai on meteorites and advising in many projects around the University concerning microprobe analysis.

RECENT PUBLICATIONS

1. G. V. Gibbs, C. R. Knowles, A. J. Perrotta, J. V. Smith, Crystal Structure Analysis of Analcime, Hydrated Ca-Chabazite, Low-Cordierite, Forsterite, Kalsilite, Miargyrite, and Pyrope. *Acta Crystallogr.* 16:10, Dec. 1963.
2. J. V. Smith, C. R. Knowles, F. Rinaldi, Crystal Structures with a Chabazite Framework. III. Hydrated Ca-Chabazite at +20 and -150 Degrees Centigrade: *Acta Crystallogr.* 17:374-384, Apr. 1964.
3. C. R. Knowles, A Redetermination of the Structure of Miargyrite, AgSbS_2 : *Acta Crystallogr.* 17:847-851, Jul. 1964.
4. C. R. Knowles, A Refinement of the Structure of Lorandite, TlAsS_2 : *Amer. Crystallogr. Ass.* 79, Jul. 1965.
5. C. R. Knowles, F. F. Rinaldi, J. V. Smith, Refinement of the Crystal Structure of Analcime: *The Inadid Mineralogist* 6(1-2): 127-140, June 1965.
6. A. L. Boettcher, A. J. Piwinskii, C. R. Knowles, Zoned Potash Feldspars from the Rainy Creek Complex Near Libby, Montana: *Earth and Planetary Sci. Letters* 3:8-10, Sept. 1967.
7. F. A. Besic, C. R. Knowles, M. R. Wiemann, Jr., O. Keller, Electron Probe Microanalysis of Non-Carious Enamel and Dentin and Calcified Tissues in Mottled Teeth: *J. Dent. Res.* 48(1): 131-139, Feb. 1969.
8. F. A. Besic, C. R. Knowles, O. Keller, M. R. Weimann, Jr., An Electron Probe Microanalysis of Early Enamel Caries, *Inter. Assoc. for Dental Res.* 541, March 1969 (abstract).
9. C. R. Knowles, J. V. Smith, A. E. Bence, A. L. Albee, X-Ray Emission Micro-Analysis of Rock Forming Minerals: VII Garnets: *J. of Geology* 77:439-451, Aug. 1969.
10. F. A. Besic, C. R. Knowles, M. R. Wiemann, Jr., O. Keller, Detailed Electron Probe Microanalysis of Three Teeth Sections with Early Enamel Caries: *J. Dent. Res.* 49(1):111-118, Feb. 1970.
11. G. A. Chinner, J. V. Smith, C. R. Knowles: Transition-Metal Contents of Al_2SiO_5 Polymorphs: *Amer. J. Sci.* 267-A:96-113, 1969.

PRATER, LEWIS S., B.S. (Montana School of Mines). Associate Director, Idaho Bureau of Mines and Geology.

RALSTON, DALE R., M.S. (University of Arizona). (Ph.D. in progress at University of Idaho). Hydrogeologist, Idaho Bureau of Mines and Geology. Assistant Professor of Hydrogeology ($\frac{1}{4}$ -time), University of Idaho.

CURRENT RESEARCH PROJECTS

1. "Systems Analysis of the Impact of Legal Constraints on Ground-Water Resource Development in Idaho". Approved for funding by Office of Water Resources Research—\$33,600—1971-73.
2. "Abandoned Tailings Piles." A chapter in a proposal on the Coeur d'Alene River drainage being prepared for submission to the U.S. Bureau of Mines.
3. "Analysis of the Availability of Ground Water for Wells in Latah and Benewah Counties, Idaho." Under Idaho Bureau of Mines and Geology.

RECENT PUBLICATIONS

1. Ralston, Dale R., 1968, Ground-Water Development in Idaho, 1967: Water Information Bulletin No. 3, Idaho Department of Reclamation.
2. Ralston, Dale R., and Sherl L. Chapman, 1968, Ground-Water Resource of the Mountain Home Area, Elmore County, Idaho: Water Information Bulletin No. 4, Idaho Department of Reclamation.
3. Ralston, Dale R., and Sherl L. Chapman, 1969, Water-Level Changes in the Mud Lake Area, Idaho, 1958-1968: Water Information Bulletin No. 7, Idaho Department of Reclamation.
4. Ralston, Dale R., 1969, Ground-Water Development in Idaho, 1968: Water Information Bulletin No. 11, Idaho Department of Reclamation.
5. Ralston, Dale R., and Sherl L. Chapman, 1969, Ground-Water Resource of Northern Owyhee County, Idaho: Water Information Bulletin No. 14, Idaho Department of Reclamation.
6. Ralston, Dale R., and Sherl L. Chapman, 1970, Ground-Water Resource of Southern Ada and Western Elmore Counties, Idaho: Water Information Bulletin No. 15, Idaho Department of Reclamation.
7. Ralston, Dale R., and Eugene J. Kozak, 1970, Ground-Water Development in Idaho, 1969: Water Information Bulletin No. 17, Idaho Department of Reclamation.

8. Chapman, Sherl L., and Dale R. Ralston, 1970, Water Resources of the Blue Gulch Area, Eastern Owyhee and Western Twin Falls Counties, Idaho: Water Information Bulletin 20, Idaho Department of Water Administration.

9. Ralston, Dale R., and Norman Young, Potential for Large Scale Development in the Twin Falls Tract: to be published in 1971 in Water Information Series.

10. Young, Norman, and Dale R. Ralston, Evaluation of Reasonable Pumping Lofts for Ground-Water Basins in Idaho: to be published in 1971.

SAVAGE, CARLETON N., M.S. (Northwestern University). Senior Geologist, Idaho Bureau of Mines and Geology. Associate Professor of Geology ($\frac{1}{4}$ -time), University of Idaho.

CURRENT RESEARCH

1. Geology and Mineral Resources of Benewah County. County Report.
2. Geologic Idaho Illustrated. Earth Science Series, Prototype.
3. Idaho Earth Science Scenic Trails. Earth Science Series, Latah-Benewah County loops.

RECENT PUBLICATIONS

1. Savage, C. N., 1965, Economic geology of carbonate rocks adjacent to the Snake River south of Lewiston, Idaho: Idaho Bur. of Mines and Geology Min Resources Rept No. 10, 26 p.

2. Savage, C. N., 1965, Historical geology of the Pend Oreille region, north Idaho: Idaho Bur. Mines and Geology Pamph. 134, 18 p.

3. Ross, S. H., and C. N. Savage, 1967, Idaho earth science: Idaho Bur. Mines and Geology Earth Sci. Series No. 1, 271 p.

4. Savage, C. N., 1968, Mass wasting: *in* the Encyclopedia of Geomorphology, v. III of Encyclopedia of Earth Sciences Series, Rhodes Fairbridge, Ed., Reinhold Book Corp., N.Y.

5. Savage, C. N., 1968, Lexicon of Idaho geologic names: Idaho Bur. Mines and Geology Info. Cir. 20, 78 p.

6. Savage, C. N., 1968, Distribution and economic potential of Idaho carbonate rocks: Idaho Bur. Mines and Geology Bull. 23, 99 p.

7. Savage, C. N., 1970, Evaluation of minerals and mineral potential of the Salmon River drainage basin in Idaho: Idaho Bur. Mines and Geology Pamph. 147, 64 p.

(d) Department of Geography (A fourth man, a new Head, is being selected.)—

ALLEN, RALPH K., M.S. (San Fernando Valley State College). (Ph.D. in progress at University of Cincinnati). Assistant Professor of Geography.

CURRENT RESEARCH PROJECTS

1. Changing Pattern of Health Facilities in Cincinnati, Ohio, from 1867 to 1969: Ph.D. dissertation, in progress.

2. A Model for the Location of Urban Facilities. Non-funded.

RECENT PUBLICATIONS

1. Culture Area Concept. Paper presented at April 1969 meeting of Ohio Academy of Sciences.

2. A Spatial History of Public Health Activities in Cincinnati, Ohio, from 1869 to 1969. Paper presented at Spatial Aspects of Comprehensive Health Planning Workshop, June 1970, sponsored by Grad. Dept. of Com. Planning, University of Cincinnati.

3. The Culture Area Concept as a Teaching Aid: *Journal of Geography*, Vol. LXX, No. 1, Jan. 1971, p. 16-18.

CALDWELL, HARRY H., Ph.D. (Clark University). Professor of Geography' Acting Head, Department of Geography.

CURRENT RESEARCH PROJECTS

1. Boundaries and Decision-Making (pending—under consideration by the Water Resources Research Inst.).

2. Idaho State Planning (pending—may be funded by the Idaho Office of Higher Education).

3. Community Development. H.U.D. grant through Title 8. In completion stage.

4. Lewiston, Idaho, Comprehensive Planning and Zoning. Funded by the City of Lewiston, Idaho. In completion stage.

RECENT PUBLICATIONS

1. Four Planning Studies for Lewiston, Idaho, 1970.
2. Study of Environmental Problems on the Public Lands—Case Study No. 1, Batholith Granitic, Idaho, Jan. 1970, Public Land Law Review Commission, Washington, D.C.
3. Paper in *Idaho Forester*, Spring, 1970.
4. Idaho Economic Atlas (Editor), Moscow, Idaho, 1970.
5. Idaho articles in *Groliers* and *World Book Encyclopedias*.

DAY, RICHARD L., Ph. D. (University of Illinois). Associate Professor of Geography.

CURRENT RESEARCH PROJECTS

1. "Phosphate Industry of Idaho." Paper to be presented at meeting of Idaho Academy of Sciences in April. Written version of report also being prepared.
2. "Temperature and Relative Humidity Traces as Climatological Site Signatures". Paper to be presented before meetings of the Association of Pacific Coast Geographers in June.
3. "Climatological Guidebook for Moscow, Idaho, and Vicinity". Data has been collected, compiled, etc.; accompanying text and actual preparation of the volume still to be done.

RECENT PUBLICATION

"A Microclimatic Profile Between the Snake River Canyon and Clearwater Mountains, Idaho", Research Technical Completion Report, Project A-012-Ida.: Water Resources Research Institute, Univ. of Idaho, Moscow, Idaho, Sept. 1968.

STATEMENT OF DR. JOHN F. ELLIOTT, PROFESSOR OF METALLURGY, MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Dr. ELLIOTT. Senator Moss, Senator Allott, it is a pleasure to appear before you in support of pending bill S. 635. I am a member of the faculty of the department of metallurgy and materials science at the Massachusetts Institute of Technology (MIT) and have spent the whole of my professional career in the field of extractive metallurgy, first as an engineer in industry and then as a researcher and teacher at MIT.

I have written a statement; I would like to pass over a number of points that have been covered before. There are several points I would like to emphasize, and I have a small comment to add at the end.

Senator Moss. You may do it that way; your full statement will be in the record.

Dr. ELLIOTT. First, I would like to say this matter of recycling of scrap steel that was brought up this morning is a very important issue, and it couples closely with the technology of steelmaking. One of the problems facing us in the years ahead is the impact of the changing technology and our scrap supply and the recycling of such things as automobile bodies through steelworks.

One of our students and I are modeling this system. It is an appropriate kind of project. It is technological in nature, but does need attention, and I think it is a very important issue before the country.

I would also like to add that this fall I traveled for a month in Japan, visiting their steelworks, lecturing, and also visiting their educational institutions at the expense of the Japanese steel companies. I came home tremendously impressed with the progress the Japanese steel industry is making, particularly in their technology.

I feel that the challenge to the American scene, to the industry, and to the educational work is a technological one; and I feel that the character and the provisions of bill S. 635, if we can handle them adequately and properly, will do much to enhance our ability to compete in such a situation.

Now, let me go to the issues that I think are important with regard to bill S. 635. On page 2, flexible and continuing support is necessary to assure vigorous programs of research and education in the areas of mineral resource development in our engineering schools.

To attract young people, the educational programs must be vigorous, be progressive, be involved in real problems, and be intellectually challenging. The provisions of bill S. 635 for continuing support of research and training offer a sound basis for revitalizing programs of mineral resource development in our engineering schools.

I would like to say something a little later about how one judges quality. Now, one of the things I decided to do in my testimony was to comment on the impact of the changes in the last two decades on the number of students and faculty involved in process metallurgy at MIT, and I have in mind here the two areas of mineral engineering and extractive metallurgy.

It is an issue that has to be faced, and I feel S. 635 will help us in that regard. In 1951, eight faculty members were working and studying in areas directly related to the field of process metallurgy. By 1961, the number had dropped to seven; and next fall, 1971, there will be but three of us, with one open position to be filled when a suitable candidate is found. In this interval, the total number of active faculty in the department was 24 in 1951, it rose to 28 in 1961, peaking at 33 between 1965 and 1969, and now is 28.

Thus, the proportion of faculty in the department who are concerned with the field of process metallurgy has declined from approximately 35 percent in 1951 to a current level of 14 percent. At the same time, there has been approximately an equivalent decline in the number of graduate students interested in the two fields. Of the total of 104 graduate students in 1951, 28 of them were in process metallurgy; in 1961, there were 28 out of a total of 156; and currently, the number is 11 out of a total of 133 students.

The decline in activities in mineral engineering has been particularly dramatic. In 1951 there were three faculty and 10 graduate students working in that area, but the numbers are now one faculty member and one student. This loss is particularly serious because between 1949 and 1955, over 50 people obtained graduate degrees in mineral engineering at MIT, and a number of others did postgraduate work in that area.

I attribute the difficulty in sustaining the programs in process metallurgy directly to the inability of obtaining financial support of research, technical development, and study in the field. The rapid rise in interest in materials science that began in the late fifties also has had a strong effect.

The large flow of funds from Government agencies for materials research provided modern facilities and equipment and attracted both faculty and students because the new emphasis was exciting. In addition, the funding of research and technological studies in the area of mineral resource development has not been popular with Government agencies, industrial sources, and research foundations.

To obtain support for our research and for our students, those of us interested in process metallurgy often pursued studies having a strong flavor of materials science rather than mineral technology. Thus, one sees the strong interaction between the nature of funding and programs in our engineering schools.

My comments are not to be construed as being critical of the work in materials science. Much of great value has been learned, but at the same time one of the byproducts of the emphasis on materials science has been to reduce the support, both in relative terms and in actual level, of process metallurgy at MIT. This has been the case with engineering schools across the Nation.

It has also served to direct the attention of most of our able young people in the related undergraduate programs away from areas pertinent to mineral resource development. I think there has been an actual negative effect because of the strong programs in materials science.

There is another important effect on the education of undergraduates in metallurgy and materials science resulting from the recent strong emphasis on materials science. Traditionally, process metallurgy has contributed a valuable technological focus to the education of students in metallurgy departments. That focus has been all but lost in many departments across the country. The result is that both faculty and students who have concentrated on materials science may not now consider work in the areas of mineral resource development to be suitable for their professional careers.

In this regard, I share Dr. Hall's concern for the nature of the educational process and the need for focus on technological issues which gives the student credit and understanding. Now, I speak further on other issues, but let me go to page 6 with regard to some administrative problems.

Now, I would like to turn to several points regarding the management and control of funds to be used in the support of research and technological development, and the training of able and qualified graduates, faculty, and practicing engineers in the general area of mineral resource development.

Flexible and continuing support of programs in our engineering schools is essential. Intermittent support leads to fragmented programs, encourages the academic opportunist, and places the programs in a bad light with the undergraduate and graduate students. The provisions of bill S. 635 in this regard are sound.

If and when the program envisaged by the bill goes into effect, it is important that there be a periodic evaluation of the quality and scope of the work and education being supported in each engineering school. As is the case with all human institutions, periodic reviews and appraisals can have a salutary effect on the work being done. Academic institutions are not exceptions.

On the other hand, such reviews should not stifle creative and ambitious activities. Bureaucratic control within and outside academia must also be restrained. In addition, I would suggest that proposals from institutions for the wide range of activities possible under the provisions of bill S. 635 be evaluated primarily on merit and on the potential for long-term enhancement of the capability for mineral resource development in the individual States and for the whole of

the United States. Unless high-quality effort is maintained, the programs in the engineering schools may fail the long-term goals of bill S. 635.

The challenge that we face for providing the personnel and the technological base necessary for meeting the current and future problems related to obtaining our supplies of minerals, metals, and fuels are essentially technological in nature. As a consequence, a given problem may involve a number of fields outside the academic areas traditionally concerned with mineral resources development.

The help of economists, chemical engineers, chemists, civil engineers, biologists, et cetera, may be needed. While a program would normally be located in the area of mineral science and technology, it is important that interdisciplinary participation in the program, where appropriate, be encouraged.

Such diversity should enhance the quality of the experience of students, faculty, and engineering staff working on projects. It should also assist materially in attracting able people into the field of mineral resource development. One senses in the phrasing of bill S. 635 that there was concern for this point as the bill was drafted. I wish to concur on the matter.

These issues that I speak of to some degree are administrative in nature and will depend upon the way the program would be administered. I would hope as the bill is considered the way we obtain high-quality effort and the checking of the programs as assurance of progress be part of the consideration, because I think it is essential to the success of what looks to me at this point to be a very useful and valuable program for the United States.

Mr. Chairman, I appreciate very much the opportunity of being heard on this matter, and I would be pleased to respond to questions.

Senator Moss. Thank you, Dr. Elliott, for a very good paper and the highlights that you delivered for us here. This bill envisions money being made available in various States. Would you think as an administrative improvement it should be grouped more into regional or specialized schools rather than have the States participating?

Dr. ELLIOTT. No; I think flexibility is desirable here, and I like the phrasing of the bill in that regard. That is, individual States, but also grouping of the State activities. I worry a little bit about the transient, the beginning of this operation. However, if all States suddenly decided they wanted to have institutes, we might suck into the system all of the capable people and to defeat the very purpose of the bill at the outset.

So again this is an administrative problem. A monitoring of the way the system starts seems to be a significant issue, and it is going to take wisdom, courage, and it may involve political issues as well as technological issues. I don't see clearly how that can be done, but it is going to take a lot of attention and care.

Senator Moss. There is a requirement of sharing the costs, which may have some lessening effect on the inrush of all the States. But your warning is noted, and it is something we ought to be carefully considering as we draft our legislation so there can be full monitoring strength to bring this into proper phase.

(Dr. Elliott's prepared statement follows:)

STATEMENT OF DR. JOHN F. ELLIOTT, PROFESSOR OF METALLURGY, MASSACHUSETTS INSTITUTE OF TECHNOLOGY, ON S. 635, APRIL 28, 1971

Mr. Chairman and members of the subcommittee, it is a pleasure for me to appear before you in support of the pending bill, S. 635. I am a member of the

faculty of the Department of Metallurgy and Materials Science at the Massachusetts Institute of Technology (MIT) and have spent the whole of my professional career in the field of extractive metallurgy, first as an engineer in industry and then as a researcher and teacher at MIT.

The programs relating to the technology of extractive metallurgy of the engineering schools in colleges and universities in the United States have suffered a serious decline in the past two decades. The state of the field as outlined by the Panel on Process Metallurgy in a recent report by the National Academy of Sciences¹ has continued to deteriorate since the report was issued. As a result of this decline, and the decline in other areas of mineral resource development, there has been a serious erosion of our ability to build the technological base and to provide the able young engineers that are essential for securing our future domestic supplies of fuels, metals and nonmetallic materials at reasonable cost and with adequate protection of the health and safety of the work force and of the quality of the nation's air, water and land. It is important to recognize that possible changes in the methods by which we extract and process our mineral resources in the future probably will cause a merging of the technologies for mining, minerals processing, metals extraction and fuels utilization. As a consequence, no one link in the chain of steps of mineral resources development can be ignored as we look to the future.

Flexible and continuing support is necessary to assure vigorous programs of research and education in the areas of mineral resources development in our engineering schools. To attract young people, the educational programs must be vigorous, be progressive, be involved in real problems, and be intellectually challenging. The provisions of bill S. 635 for continuing support of research and training offer a sound basis for revitalizing programs of mineral resource development in our engineering schools. To illustrate the importance of the nature of funding to programs of research and training in engineering, I will discuss briefly the decline in process metallurgy at MIT in the past two decades. The specific areas of interest are mineral engineering and extractive metallurgy. In addition, I would like to offer a few comments on several points that may help to assure the effectiveness of the program envisioned in the bill.

Process metallurgy has been an integral part of the Department of Metallurgy² at MIT for many years, and it has been a major source of research and of trained manpower for the field of process metallurgy in the United States since the founding of MIT in 1861. In our department, the basic unit of operation for research is a faculty member and his graduate students, which over the years have averaged between 4 and 5 students working with each faculty member. Thus the number of faculty members concerned with the areas of mineral engineering and extractive metallurgy provides a good index of the research and teaching activities in process metallurgy.

In 1951, eight faculty members were working and studying in areas directly related to the field of process metallurgy. By 1961, the number had dropped to seven, and next fall (1971) there will be but three of us, with one open position to be filled when a suitable candidate is found. In this interval, the total number of active faculty in the Department was 24 in 1951, it rose to 28 in 1961, peaking at 33 between 1965 and 1969, and now is 28. Thus the proportion of faculty in the Department who are concerned with the field of process metallurgy has declined from approximately 35 percent in 1951 to a current level of 14 percent. At the same time, there has been approximately an equivalent decline in the number of graduate students interested in the two fields. Of the total of 104 graduate students in 1951, 28 of them were in process metallurgy, in 1961 there were 28 out of a total of 156, and currently the number is 11 of a total of 133 students.

The decline in activities in mineral engineering has been particularly dramatic. In 1951 there were three faculty and 10 graduate students working in that area, but the numbers are now one faculty member and one student. This loss is particularly serious because between 1949 and 1955, over 50 people obtained graduate degrees in mineral engineering at MIT, and a number of others did post-graduate work in that area.

I attribute the difficulty in sustaining the programs in process metallurgy directly to the inability of obtaining financial support of research, technical development, and study in the field. The rapid rise in interest in materials science that began in the late 50s also has had a strong effect. The large flow of funds from government agencies for materials research provided modern facilities and

¹"Mineral Science and Technology: Needs, Challenges and Opportunities." A report by the Committee on Mineral Science and Technology of the National Academy of Sciences—National Academy of Engineering—National Research Council, Washington, D.C., 1969.

²The departmental name was changed to the Department of Metallurgy and Materials Science in 1967.

equipment and attracted both faculty and students because the new emphasis was exciting. In addition, the funding of research and technological studies in the area of mineral resource development has not been "popular" with government agencies, industrial sources and research foundations. To obtain support for our research and for our students, those of us interested in process metallurgy often pursued studies having a strong flavor of materials science rather than mineral technology. Thus one sees the strong interaction between the nature of funding and programs in our engineering schools.

My comments are not to be construed as being critical of the work in materials science. Much of great value has been learned, but at the same time one of the by-products of the emphasis on materials science has been to reduce the support, both in relative terms and in actual level, of process metallurgy at MIT. This has been the case with engineering schools across the nation. It has also served to direct the attention of most of our able young people in the related undergraduate programs away from areas pertinent to mineral resource development.

There is another important effect on the education of undergraduates in metallurgy and materials science resulting from the recent strong emphasis on materials science. Traditionally, process metallurgy has contributed a valuable technological focus to the education of students in metallurgy departments. That focus has been all but lost in many departments across the country. The result is that both faculty and students who have concentrated on materials science may not now consider work in the areas of mineral resource development to be suitable for their professional careers.

One might ask why the support of programs in process metallurgy should not be the responsibility of the minerals and metals industries. The first point is that we at MIT have worked diligently at the problem for over two decades and have obtained consistent support from only a few organizations, particularly the American Iron and Steel Institute, but clearly the level of support generally has not been sufficient to sustain a strong, viable program. The second is that research is needed on many problems of importance to the community, to the state, or to the nation that industry does not and would not support for a variety of reasons. Accordingly, the provisions of bill S. 635 for support are appropriate to the need.

Now I would like to turn to several points regarding the management and control of funds to be used in the support of research and technological development and the training of able and qualified graduates, faculty and practicing engineers in the general area of mineral resource development.

Flexible and continuing support of programs in our engineering schools is essential. Intermittent support leads to fragmented programs, encourages the academic opportunist, and places the programs in a bad light with the undergraduate and graduate students. The provisions of bill S. 635 in this regard are sound.

If and when the program envisaged by the bill goes into effect, it is important that there be a periodic evaluation of the quality and scope of the work and education being supported in each engineering school. As is the case with all human institutions, periodic reviews and appraisals can have a salutary effect on the work being done. Academic institutions are not exceptions. On the other hand, such reviews should not stifle creative and ambitious activities. Bureaucratic control within and outside academia must also be restrained. In addition, I would suggest that proposals from institutions for the wide range of activities possible under the provisions of bill S. 635 be evaluated primarily on merit and on the potential for long-term enhancement of the capability for mineral resource development in the individual states and for the whole of the United States. Unless high quality effort is maintained, the programs in the engineering schools may fail the long-term goals of bill S. 635.

The challenge that we face for providing the personnel and the technological base necessary for meeting the current and future problems related to obtaining our supplies of minerals, metals and fuels are essentially technological in nature. As a consequence, a given problem may involve a number of fields outside the academic areas traditionally concerned with mineral resource development. The help of economists, chemical engineers, chemists, civil engineers, biologists, etc. may be needed. While a program would normally be located in the area of mineral science and technology, it is important that interdisciplinary participation in the program, where appropriate, be encouraged. Such diversity should enhance the quality of the experience of students, faculty, and engineering staff working on projects. It should also assist materially in attracting able people into the field of mineral resource development. One senses in the phrasing of bill S. 635 that there was concern for this point as the bill was drafted. I wish to concur on the matter.

Mr. Chairman and members of the subcommittee, thank you for the opportunity of being heard on this bill. I would be pleased to respond to questions.

Senator Moss. Professor Falkie is head of the Department of Mineral Engineering at Penn State. We will be glad to hear from you, sir.

STATEMENT OF DR. THOMAS V. FALKIE, HEAD, MINERAL ENGINEERING DEPARTMENT, AND CHAIRMAN, MINERAL ENGINEERING MANAGEMENT PROGRAM, COLLEGE OF EARTH AND MINERAL SCIENCES, THE PENNSYLVANIA STATE UNIVERSITY

Dr. FALKIE. Thank you, Senator.

I think one of the most disturbing aspects of the whole situation is that by and large there is a widespread unawareness that we are living in a mineral-dependent civilization. We would be hard pressed to find more than a few nonliving things if any in this room that are not made with or from mineral materials.

The mineral industry, like agriculture, is a basic industry. As a matter of fact, even our agricultural products are helped to grow by mineral fertilizers and our cattle are nourished by feeds containing minerals. There are people in the industry who don't realize we are in the middle of a tremendous revolution, a situation that basically amounts to the fact that it is no longer going to be possible to plan, design, and develop and operate mines by the seat of their pants.

There are many causes for this. The strict health and safety laws, the clamor for better environment and the clamor for production are among them. So the business of producing minerals is highly complex and mechanized and I think it is time we recognize this fact. All of this means that more engineering, better management, and new technology are badly needed to accomplish these ends and this means more trained people as we have already seen today.

Even now the demand for trained people at all levels is fantastic. Our graduates are going out on an average salary of \$975 a month and the number of job offers is practically unlimited. In my judgment this demand is going to continue to be high because the ratios of technical employees to capital expenditures and technical employees to non-technical employees are low when compared to other highly complex and mechanized industries.

Even today there are mining companies who need mining engineers and don't even know they need them. With the exception of some funding provided by the Coal Mine Health and Safety Act, it is almost impossible for mining schools to find adequate research funding.

We like to believe we are practical people and we like to believe that the present problems requiring solutions are obtainable primarily through applied research and that a reversal of national policy is needed where Federal funding has been strongest in the fundamental science areas.

The nice thing about S. 635 is that it gives some recognition that the mineral industry is a basic industry and there are applied problems to be solved. So our problem is to develop the objective problem-solvers and develop the technology for solving the problems.

But we have our backs up against the wall and you heard about the student credit-hour crunch here today. My own personal opinion is that if the professional educators who are running our universities

today continue with this crunch without recognizing the professionals, that there aren't going to be any professional schools, let alone mining schools.

So, they are screaming to us to build up enrollments and get more research funds; and you have already heard how many mining schools have faltered and some others are still in trouble. There are some people who feel that the mineral engineer can be replaced by people from other disciplines. But I disagree. It would be absurd to deny that the mining industry needs mechanical, civil, electrical engineers and people from other disciplines. In addition to filling the numbers gap and specialized needs, these people can provide thinking from a different viewpoint.

But how many of them are really eager to work underground and get their hands dirty and how many are willing to go into uncivilized areas to develop new mining operations and how many theoretical physicists will stay with us if jobs become available elsewhere?

Most importantly, how many of these really have the training to understand engineering and manage a mining or milling operation as complex system? There is a body of knowledge that is unique to the mining engineer, including rock breakage, exploitation methods, bulk materials handling, mine hygiene and environmental control, and perception of the mineral production as a system.

So, I think it is mandatory that we save this field from extinction and I feel S. 635 is definitely a step in the right direction. So it is a crucial time for the mining schools. Pennsylvania, depending upon which set of statistics one looks at, is either the first or second largest mineral producer in terms of dollar value.

We have along with the progress that has come with this mineral development a number of problems of the coal mine health and safety, which is a serious one. Pennsylvania's laws are among the toughest in the Nation. The acid mine waters have polluted hundreds of miles of streams and this has led to a tough clean-stream law and a research and development program to develop better ways to prevent acid water and cure it.

The strip mines and quarries have created serious disruption in the land surface. I don't want to give the impression that these problems have been solved, because they most certainly have not, and much more research and technological development are needed.

But I do want to point out that one of the country's leading mining schools, our own College of Earth and Mineral Sciences, through its research and people has been a leader in the progress that has been made to date just as many of the other mining schools have led the way toward solving similar problems in other areas.

We have one of the most comprehensive units of its kind in the free world devoted to the nonliving natural resources and I have listed some of the various departments in my testimony, Senator, including the fact that the college can call on other units, including the large agricultural college, to help on interdisciplinary efforts as has been suggested here today.

The college in itself is interdisciplinary in a sense that it contains engineering, science, and nontechnical groups and I might mention parenthetically that we most certainly support the matching funds criteria in the bill S. 635.

We have about 1,100 students in the college and we do over \$3 million worth of research each year, ranging from ore genesis to determining the effects of air effluents on the atmosphere. Once again I would like to emphasize that research funds for the applied engineering group have been hard to find. To show you the kind of research that could be done if funding were excellent, let's use land reclamation. Despite the fact that there has been a lot of emotional clamor over this problem and despite the large amount of proposed legislation in the Congress, it is very difficult if not impossible to get funding to do research in the problem of restoring mined lands.

My own personal belief is that land reclamation will have to become part of the mining cycle but I would like to do some research to develop the methodology for accomplishing this. Another example is the problem of old mine wastes for which we are already doing some research but this has to be attacked from three standpoints. First of all, we have to be able to restore the land; secondly, we have to be able to find a use for these mine wastes; and, thirdly, we have to be able to find a way of extracting the valuable minerals from these wastes for conservation purposes.

But it is very hard to find funding and do this type of research. Most of my remarks are directed toward mining and mineral beneficiation, but I would like, with your kind permission, to introduce a written statement by my colleague, Dr. C. Drew Stahl, chairman of our petroleum engineering group, pertaining to the problem of petroleum engineering.

Senator Moss. That may be introduced and made part of the record.

Dr. Falkie's prepared statement and the statement by Dr. C. Drew Stahl, referred to by Dr. Falkie, follow:

STATEMENT OF DR. THOMAS V. FALKIE, HEAD, MINERAL ENGINEERING DEPARTMENT, AND CHAIRMAN, MINERAL ENGINEERING MANAGEMENT PROGRAM, COLLEGE OF EARTH AND MINERAL SCIENCES, THE PENNSYLVANIA STATE UNIVERSITY, UNIVERSITY PARK, PA.

By and large there is a widespread unawareness that we are living in a mineral dependent civilization. We would be hard pressed to find more than a few non-living things, if any, in this room that are not made with or from mineral materials. The mineral industry, like agriculture, is a *basic* industry. As a matter of fact, even our agricultural products are helped to grow by mineral fertilizers, and our cattle are nourished with feeds containing minerals.

To say that the demand for minerals is increasing would be an understatement; and failing to recognize that the sources of supply for many of them are limited could be disastrous. Here in our own country we depend upon electrical power to drive our highly developed and industrialized economy. Most of this power must be made from mineral fuels—coal, oil, gas and uranium—and recently the ability to supply some of these minerals and to produce sufficient amounts of power have been causes for some concern.

The mining community in this country is right in the middle of a tremendous revolution, a situation whose implications are not fully recognized by some mining people. Basically what this revolution amounts to is the fact that it is no longer going to be possible to plan, design, develop and operate mines by "the seat of the pants." There are many causes for this. First, the need for additional supply and the decreased self sufficiency of our own country mean that we must develop more economical ways to extract minerals. Second, the need to improve health and safety conditions in mines, as manifested in recent tough legislative efforts in this area, is foremost in the thoughts of progressive mining people. Third, the pressures to preserve and improve our environment are well known to all of us in this room. The business of producing minerals is highly complex and mechanized, and it is time that we recognize this fact.

What all this means is that more engineering, better management, and new technology are badly needed to accomplish these goals. This means more trained people and much more research, and that is why we are here today.

Even now the demand for trained people at all levels is fantastic. At a time when most other fields are having trouble getting jobs, B.S. mining engineering graduates from Penn State are leaving this year at average starting salaries of \$975 per month with five to six good job offers each. This immediate demand for people is caused by the need for increased production, especially coal. In my judgement the demand is going to continue to be high because the ratios of technical employees to capital expenditures and of technical employees to non-technical employees in the mining industry are low when compared to other highly complex and mechanized industries. There are mining companies who need more mining engineers and don't even know that they need them.

On the research end, with the exception of some funding provided by the Coal Mine Health and Safety Act, it is almost impossible for the mining schools to find adequate funding. For the most part, we are practical people who attempt to solve real problems in applied ways. This has worked against us in the sense that we have not been supported by NSF, AEC, and other funding agencies, whereas our colleagues in materials science, the geological sciences, and other scientific and engineering disciplines have been able to find continuing support from various sources. The present problems require solutions obtainable primarily through applied research and a reversal of national policy where federal funding has been strongest in fundamental science areas. Really, the nice thing about Senate Bill 635 is the fact that it finally gives some recognition that mineral engineering is a *basic* industry, just like agriculture which has been supported by continuing funds for many years.

The mining schools are devoted to developing objective problem solvers and the technology needed for solving problems. Yet we find ourselves in a paradoxical situation with our backs up against the wall. On the one hand the mining community badly needs trained people and more research, as previously mentioned; on the other hand university administrators are screaming at us to build up enrollments and get more research funds. As you know, many of our mining schools have already folded and some others are in trouble.

There are some who feel that the mineral engineer can be replaced by people from other disciplines, but I disagree. It would be absurd to deny that the mining industry needs mechanical, civil, chemical and electrical engineers and people from other disciplines. In addition to filling the numbers gap, these people can provide thinking from a different viewpoint. But how many of them are willing or eager to work underground and get their hands dirty? How many are willing to go into uncivilized areas to develop new mining operations? How many theoretical physicists will stay with us if jobs become available elsewhere? And, most importantly, how many of these people have the training to understand, engineer and manage a mining or milling operation as a complex system? In addition, there is a body of specialized knowledge that is unique to the mining engineer including rock breakage, exploitation methods, bulk materials handling, production and cost control, mine hygiene and environmental control and perception of mineral production as a system. I think it is mandatory that we save this field from extinction and I feel that S. 635 is definitely a step in the right direction.

And so it is that this is a crucial time for our mineral industry and our mining schools. I would like to describe very briefly the capability of university based research by using our own state and our own school as examples. Depending upon which set of figures one uses, the Commonwealth of Pennsylvania is either the first or second largest producer of minerals in terms of dollar value. You are probably aware that oil was first discovered in Pennsylvania, that its coal industry has been a prime energy supplier since well into the past century and that its crushed stone, sand and gravel industry is significant. But progress in the mineral area over the years has brought with it some serious problems. The coal mine health and safety problem is a serious one, and Pennsylvania's laws are among the toughest in the nation. The acid mine waters from our underground and surface coal mines have polluted hundreds of miles of streams, and this has led to a tough clean stream law and a research and development program to develop better ways to prevent acid water and to cure it. The strip mines and quarries have caused serious disruptions in the land surface, and this has resulted in one of the strictest surface mining laws in the country. I do not want to give the impression that these problems have been solved, because they most certainly have not and much more research and technological development are needed. But I do want to point out that one of the country's leading mining schools, Penn State's College of Earth and Mineral Sciences, through its research and its people, has been a leader in the progress that has been made to date just as many of the other mining schools have led the way toward solving similar problems in other areas.

The College of Earth and Mineral Sciences is one of the most comprehensive units of its kind in the free world devoted to the nonliving natural resources. It is organized as follows, with Assistant Deans for coordinating the prime functions of Resident Education, Research, Continuing Education and Public Service (see Exhibit 1 for organization chart).

The Geologic Sciences:

Geochemistry and Mineralogy Department and Geology and Geophysics Department.

Material Sciences Department:

Ceramic Science, Fuel Science, Metallurgy (physical and extractive), Solid State Sciences, and Carbon Polymers.

Meteorology Department

Geography Department

Mineral Economics Department

Mineral Engineering Department:

Mining Engineering, Petroleum and Natural Gas Engineering, and Mineral Engineering Management.

Interdisciplinary Research Sections:

Ore Deposits Research Section, Coal Research Section, Mass Spectrometry Section, Mineral Constitution Laboratories, Mine Drainage Research Section, and Mineral Conservation Section.

Continuing Education Functions:

Short Courses, Conferences, Correspondence Courses, and Certificate Programs.

The college is a good example of the systems approach to resource problems. All of the departments have outstanding research facilities and extensive programs. For example, the mining group has a modern rock mechanics laboratory, a ventilation laboratory, a million dollar mine drainage research facility and access to mines all over the state. They have B.S., M.S. and Ph.D. programs, a very successful work-study program, a two-year Associate Degree program in Mining Technology at one of the branch campuses, a Manpower Development and Training Act program for training unemployed men to become mine mechanics, a proposed program to train mine machine operators, and a very extensive statewide continuing education program. This group also has a new graduate program for nonmineral engineers in which we hope to retrain unemployed engineers for use in the mineral industry. The research projects in mining include a study on the safety of underground electric systems, a project to determine the feasibility of using microseismics for predicting roof falls, projects in materials handling, a study to predict optimum underground gas storage pressures, a number of studies to increase mine productivity and some others.

In addition, the college can call on other units, including a large Agriculture College, to help on interdisciplinary efforts. The college in itself is interdisciplinary in the sense that it contains engineering, science and non-technical groups.

There are about 1100 students in the college and we do over three million dollars of research each year ranging from ore genesis to determining effects of air effluents on the atmosphere. But, once again, I must emphasize that research funds for the applied engineering group have been hard to obtain. To show you the kinds of research that could be done if funding were available, let's use land reclamation as an example. Despite the recent emotional clamor over the land reclamation problem and despite the large amount of proposed legislation on surface mining in the Congress and in State Legislatures, it is very difficult, if not impossible, to get funding to do research in the problem of restoring mined lands. My own personal belief is that land reclamation will have to become part of the mining cycle, but much research must be done to develop the methodology for accomplishing this. We would study this problem with an interdisciplinary approach, using the mining engineer, the hydrologist, the agricultural people and the mineral economist. Another example is the problem of old mine wastes, for which we are already doing some research. This problem must be attacked from different angles in order to find uses for the waste materials, recover the mineral values from it for conservation purposes, restore unsightly waste piles, and prevent them from becoming fire and pollution hazards. An interdisciplinary approach is also advantageous in this case. There are many, many other problems which could be solved if our country decides to put forth an effort similar to what we have done in agriculture.

There is one other aspect of the mining education business that deserves to be mentioned here. Most schools have a philosophy of tying together their graduate

programs with their research efforts. From the graduate students, of course, come the researchers and educators of the future. The plain facts are that we are having trouble getting people to come to graduate school and most of the graduate students are foreign. There are a number of reasons for this. First, the total number of mining engineering graduates in this country is small. Second, it is very attractive for these B.S. graduates to take the high paying jobs in industry and government. Third, the level of support for our graduate programs has been low, as we have said before. Please be assured that we are taking drastic steps to improve the graduate student situation also. S. 635 will be a big help.

Incidentally, Penn State is the land grant college in Pennsylvania and the state has supported its mining school continuously since the 1880s. As you can imagine, there has been rough sledding from time to time. We support the matching funds criterion of S. 635 because we feel we will have no trouble getting support for this commitment from the University and the Commonwealth.

Most of my remarks so far have been about mining and mineral beneficiation, the applied solid mineral engineering fields. Before concluding, I would like to say a few words about our colleagues, the Petroleum and Natural Gas engineers. With your kind permission, I would like to introduce for the record a written statement by Dr. C. Drew Stahl, Chairman of our Petroleum Engineering Group at Penn State. While the petroleum engineering situation is not quite so bad as mining, it certainly is not good. Just about everything we have already said also applies to the petroleum area. With support for university-based research centers we could be doing work towards solving problems such as production of oil from shales, applied techniques of tertiary recovery of oil for conservation purposes, feasibility of disposal of liquid and gaseous waste materials in deep sands, more research in gas storage techniques and many others. At this point in the game it would be presumptuous of me to expound further on the problems of petroleum self sufficiency because some of the members of your committee are from leading oil producing states. I recommend Dr. Stahl's remarks for your reading.

In conclusion, I wholeheartedly support S. 635 because, if administered correctly, it will

1. Be a step toward saving the mineral engineering schools, which are a prime source of people and research for an industry that is basic to our way of life. The mining schools should be used as a force for third party credibility, along with industry and government, to help produce the leaders and technology and to help solve the highly emotional problems of our day in an independent, objective way. They have a tremendous specialized and applied research capability which can be used to the advantage of mankind in a mineral-dependent civilization.

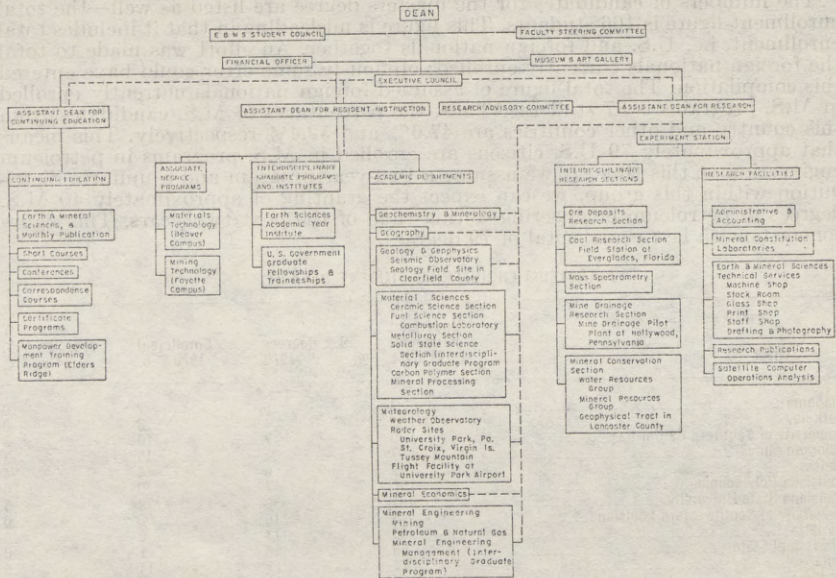
2. Be a step toward solving the complex applied technological problems associated with health and safety, environmental control, conservation of mineral resources and meeting our production requirements.

3. Finally begin to give recognition and support, such as agriculture has had, to the mineral industry as a *basic* industry in our country.

Thank you for giving me the opportunity to appear before you and present this statement.

THE PENNSYLVANIA STATE UNIVERSITY

ORGANIZATION OF THE COLLEGE OF EARTH & MINERAL SCIENCES



STATEMENT OF DR. C. DREW STAHL, CHAIRMAN, PETROLEUM ENGINEERING SECTION, COLLEGE OF EARTH AND MINERAL SCIENCES, THE PENNSYLVANIA STATE UNIVERSITY, UNIVERSITY PARK, PA.

PETROLEUM ENGINEERING SCHOOLS

The Society of Petroleum Engineers of AIME lists 24 institutions offering degrees in petroleum engineering and closely allied areas of work. This is not to say that there are 24 departments of petroleum engineering; rather there are currently 20 departments while 4 organizations are listed as options within other degree-granting groups. One of the 20 departments will shortly be changed to the option status—another group listed as an option will cease to grant degrees this June. Thus, by July 1, 1971 we shall have 19 petroleum engineering departments and four options operating in this country. One school offers degrees in natural gas engineering only while another institution grants degrees in petroleum science rather than in petroleum engineering.

All of the schools offer the bachelor's degree, ten schools offer bachelors and masters degrees and twelve offer programs through the doctorate.

The schools are distributed geographically as follows with the number in parentheses indicating the number of degree granting institutions in the respective states: Texas (4), Louisiana (3), California (3), Oklahoma (2), Pennsylvania (2), and Alabama, Colorado, Kansas, Ohio, Mississippi, Missouri, Montana, New Mexico, West Virginia and Wyoming each have one school. It is apparent that the distribution of petroleum engineering schools is not geographically uniform; rather there are concentrations of departments in the Southwest and West. Only six schools are located east of the Mississippi River; one of these will cease to function in June leaving Pennsylvania and the Northeast with only one academic unit active in petroleum engineering education.

PETROLEUM ENGINEERING ENROLLMENTS

The enrollments of the respective schools are listed on the attached tables. It can be seen that the total undergraduate enrollment during the Fall Term of 1970 is 1748 students with the range between schools being quite large. A concentration of undergraduate students occurs in the Southwestern States.

If an average rate of graduation is assumed—say 75 percent—an ultimate total of 1311 bachelors degrees will be granted during the next four years—an average of 328 per year. This figure agrees with the total bachelors degrees granted in 1970, i.e. 327.

The undergraduate enrollment figure has stayed relatively constant over the past five years; actually, the figure for this year shows a slight increase. It is clear, though, that no dramatic change in enrollment is about to occur.

The numbers of candidates for the masters degree are listed as well—the total enrollment figure is 166 students. This figure is misleading in that it includes total enrollment, i.e. U.S. and foreign nationals together. An effort was made to total the foreign nationals currently enrolled; obviously some error could have entered this compilation. The total figure of assumed foreign nationals currently enrolled in M.S. programs is 87 students. Thus, the percentages of M.S. candidates from this country and other countries are 47.6% and 52.4% respectively. This means that approximately 79 U.S. citizens are enrolled in M.S. programs in petroleum engineering at this time. If we assume a two-year program and a uniform distribution within this group, we can expect the granting of approximately 40 M.S. degrees in petroleum engineering during each of the next two years. This figure contrasts with last years' total of 79 degrees.

PETROLEUM ENGINEERING STUDENT DATA (1)

School	Undergrad enrollment 1970-71	B.S. degrees 1970	Enrollment 1970 M.S.	Foreign M.S. students
Alabama	4	6	2	0
Berkeley	8	4	3	0
University of Southern California	40	7	10	3
Colorado Mines	97	31	16	3
Kansas	19	6	4	4
Louisiana Polytechnic	50	7	0	0
Louisiana State University	101	36	8	5
University of Southwestern Louisiana	76	16	0	0
Marietta	85	13	0	0
Mississippi State	63	13	1	0
Rolla	74	11	14	5
Montana	123	10	3	1
New Mexico	33	7	2	0
Oklahoma	149	30	12	5
Pennsylvania State University	63	7	17	10
Pittsburgh	20	8	3	1
Stanford	5	4	5	4
Texas	148	14	22	14
Texas A. & I.	102	20	0	0
Texas A. & M.	144	12	8	5
Texas Tech	78	14	0	0
Tulsa	163	26	28	22
West Virginia University	21	7	5	5
Wyoming	82	18	3	0
Total	1,748	327	166	87

PETROLEUM ENGINEERING STUDENT DATA (2)

School	M.S. degrees 1970	Ph. D. degrees 1970	Ph. D. enrollment 1971	Foreign Ph. D. students
Alabama	1	0	0	0
Berkeley	3	1	(1)	0
University of Southern California	10	1	8	5
Colorado Mines	4	0	2	0
Kansas	4	2	1	0
Louisiana Polytechnic	0	0	1	1
Louisiana State University	2	0	0	0
University of Southwestern Louisiana	5	0	0	0
Marietta	0	0	0	0
Mississippi State	1	0	0	0
Rolla	1	0	0	0
Montana	3	2	1	0
New Mexico	1	0	0	0
Oklahoma	3	0	0	0
Pennsylvania State University	3	3	5	1
Pittsburgh	4	2	5	2
Stanford	2	1	0	0
Texas	7	5	12	7
Texas A. & I.	11	3	21	11
Texas A. & M.	0	0	0	0
Texas Tech	3	0	2	1
Tulsa	0	0	0	0
West Virginia University	12	1	10	2
Wyoming	2	0	0	0
Total	79	21	68	30

¹ Not available.

Data pertaining to doctoral-degree enrollments are also listed; the current total enrollment is about 68 students—one school did not provide data—of which 38 are presumably American citizens and 30 are foreign nationals. Here we can assume a three year program with a completion rate of 13 doctorates per year if, in fact, all the listed candidates successfully complete their programs.

It is obvious that the future supply of petroleum engineers will be severely limited. It would appear that the number of candidates for advanced degrees in this field of study is anomalously low. While a comparable data from other disciplines are not immediately available, it would seem that the numbers of advanced-degree candidates would be larger in many other instances.

REASONS FOR LOW ENROLLMENT IN GRADUATE PROGRAMS

Appended is a copy of an article from the December 1970 issue of the *Journal of Petroleum Technology* and also a copy of an article from the October 1970 issue of the same publication. These articles point out several of the reasons for low enrollment in graduate petroleum engineering programs.

1. *Competition from Industry.*—The Society of Petroleum Engineers reports that petroleum engineering graduates with B.S. degrees received an average of 3.8 job offers in 1970. This figure is revealing—a more striking figure would be the number of job offers made to the top 20 percent of the graduating class, the people who would have been acceptable as graduate students. Our experience was that really well qualified men received as many as 10 job offers! Employment prospects are important but starting salaries are equally important. During 1970 the average starting salary of B.S. petroleum engineers was \$920.00 per month; the range was from \$700.00 to \$1,000.00 per month. These figures are indicative of the demand in the past for B.S. petroleum engineers. Certainly these people would consider such offers with care.

2. *Lack of Financial Support of Graduate Programs.*—Traditionally, the level of financial support for graduate and research programs in petroleum engineering has been low. For whatever reason or reasons, there has been no federal program such as the NSF in this area. Rather, support has come from (1) internal budgets in the universities, (2) limited state appropriations and (3) aid from industry. Combinations of these sources of income have been insufficient, generally, to permit competition with industry for students to become research assistants and to permit the departments to develop expanding research programs. The costs of research and graduate programs have risen several times faster than the available funds for research and graduate work. Support from industry, while not inconsiderable, has been directed primarily toward undergraduate scholarships. This aid has been of value in that it has helped maintain a sort of status quo with regard to undergraduate enrollment—it has not been of great value in the areas of graduate work and research. The fact is that major petroleum companies, unlike those of the other extractive industries, have large and active research laboratories of their own; they need not be directly interested in maintaining levels of research at educational institutions.

A basic problem is, of course, the shortage of petroleum engineering graduates. This factor, more than any other, accounts for the fact that the enrollment of American citizens in graduate programs is so low. The anomalous situation, of course, is that foreign governments are sufficiently aware of the importance of this area of work to offer financial support to their student engineers while this country is not.

AREAS OF SPECIAL PROBLEMS

There are many areas of concern in the petroleum engineering education and research sectors. Several of those are discussed below.

1. *The General State of the Educational Units.*—It is worth pointing out that several departments and options have ceased to operate in the past several years. Included in this list are North Dakota University, University of Houston and Oklahoma State University while the University of Pittsburgh will abandon the field in June 1971. Practically no department or option in the country is showing marked growth at a time when the energy and fuel picture of the nation shows need of energetic action and study. By any measure, the present prognosis for the discipline can only be considered to be bleak.

2. *Future Supplies of Oil and Gas.*—According to a study by the petroleum Industry Research Foundation this nation's energy consumption since 1965 has been rising at a rate of 5% per year. One study revealed the use of 71 quadrillion B.T.U. in 1970; of this total 23.8 quadrillion were derived from natural gas and 31.4 quadrillion from oil. A forecast for 1980 predicts the use of 105.8 quadrillion B.T.U. of which 23.8 will be supplied by gas and 47.9 by oil. The increased demands will put extreme pressure on the technology and the industry.

The present situation is that the proved reserves of oil in the United States are 39 billion barrels of oil and 291 trillion cubic feet of gas. Proved reserves are those quantities which can be economically produced with present-day technology. The potential reserves are 432 billion barrels and 1,543 trillion cubic feet respectively. The potential reserves include the oil from shales which cannot be produced economically at this time. Moreover, production of shale oil involves (1) strip mining and (2) the production of literally mountains of waste material, two considerations which are obviously unsound in view of the present trend of concern for the environment and the ecology.

Outside sources of supply are questionable—Venezuela has limited capacity, the Middle East is politically unstable and an optimistic assumption of supply from the North Slope in 1980 amounts to only 2,000,000 barrels per day. The most reasonable source of energy from oil and gas is from existing fields in this country. *The problem is the production of the required volumes from existing fields.*

The Commonwealth of Pennsylvania illustrates the supply situation rather well in that the industry of the Commonwealth provides a scale model of the industry in general. The petroleum industry in Pennsylvania produced 4.5 million barrels of petroleum in 1969—the proved reserves were 54.7 million barrels at that time and cumulative production through 1969 was 1.265 billion barrels. The Penn Grande Crude Oil Association, however, estimates that over half of the original oil in place in Pennsylvania remains unrecovered in existing reservoirs. This being so, there exist over a billion barrels of Penn Grade oil of which 54.7 million barrels can be economically recovered (with little or no danger to the environment) with present technology. The inference cannot be made to extend these figures to all parts of the nation although the basic problem, i.e. a lack of technology to produce in-place reserves economically, applies to all parts of the country.

3. *Lack of a National Research Policy.*—There does not exist a national research policy with regard to minerals in general and fossil fuels in particular. Research in the Bureau of Mines—for whatever reason—has not been notably effective. What is needed is a broad-based research policy beyond the scope of the Bureau—to attempt to solve increasingly urgent problems in the minerals area. Specific problems should be attacked in the oil and gas sections; some of these are listed below.

- (a) A comprehensive evaluation of present and future producing capacities.
- (b) A long-range study of the physical characteristics of oil sands and their interactions with fluids.
- (c) Study of the factors governing flow in carbonate reservoirs.
- (d) Theoretical and applied techniques of tertiary recovery of oil.
- (e) A feasibility study of (1) the wide-scale disposal of liquid and gaseous waste materials in deep sands.
- (f) Development of methods of the production of shallow high-viscosity oils.
- (g) Study of the possible disposition of thermal pollution in deep reservoirs.
- (h) The possible use of waste heat to increase oil production from low permeability reservoirs.
- (i) Long-range study of the dislocation of traditional sources of supply—i.e., what will occur when the present supply of Eastern gas is depleted?
- (j) Research in gas storage techniques—this procedure is certain to grow in importance.
- (k) Research in the storage of LNG—ultimately the East Coast will be heavily dependent on LNG and storage will be required. How can it best be done?

These and other specific problems should be attacked now if the country is not to become almost totally dependent on external supplies of oil and gas in the future.

There exist, however, two basic problems. The first and more pressing is technical manpower. An adequate research program to handle even a portion of the required work would require more personnel than are presently being trained. The second problem is, of course, continuing funding—the traditional sources of support are in no way capable of funding a research program of the required magnitude.

RECOMMENDATIONS

The implementation of a national research policy in support of mineral engineering education and research with the establishment of university-based research centers is highly recommended. We strongly support S. 635 of the 92nd Congress (1st Session) as a way to do this.

[From Journal of Petroleum Technology, October 1970]

JOB OFFERS FOR PE GRADUATES DECLINE—STARTING SALARIES RISE

Petroleum engineering graduates of U.S. colleges and universities in 1970 fared considerably better in the job market than their engineering counterparts from other disciplines. Figures released by the SPE Education and Accreditation Committee and the Engineering Manpower Commission indicate that, while 4 percent of the nation's engineering graduates went without job offers following spring graduation, the average petroleum engineering graduate received 3.8 job offers.

The study by the SPE E&A Committee revealed that petroleum engineering graduates with BS degrees received fewer job offers than did 1969 graduates (3.8 compared with 5.2), but starting salaries continued to rise, with the average offer reaching \$920 per month, or about \$60 per month above the 1969 level. Salary offers for BS degree graduates ranged from \$700 to \$1,000 per month, compared with \$625 to \$935 per month in the 1969 survey.

The SPE report covered 125 graduates from 20 schools, or about 30 percent of the total number of petroleum engineering BS degree graduates of U.S. colleges and universities. The average of all minimum salaries reported was \$848, and the average of all minimum salaries reported was \$848, and the average of all maximum offers reported was \$971. The SPE report was prepared by a subcommittee of the Society's E&A Committee. W. W. Owens, Pan American Petroleum Corp. in Tulsa, was chairman of the work group.

The Engineering Manpower Commission report covered 44,000 graduates from more than 260 U.S. colleges, universities and technical schools. It showed that for the first time in 7 years, the BS degree graduate in engineering was experiencing more difficulty in securing job offers. Hardest hit, according to the report, were the doctoral-degree engineers; of these 1970 graduates, almost 10 percent reported having no job offers or other plans.

SOCIETY HONORS MEMBERSHIP WINNERS AT HOUSTON MEETING

SPE added the sixth 100-member award winner to its ranks during the Society's Fall Meeting in Houston. Presentation of the award plus recognition of five local sections for outstanding membership development work were among highlights of the Membership Luncheon.

Robert L. "Bob" Johnson, regional drilling engineer in Houston for Sun Oil Co., received SPE's highest award in the membership development area. The 100-member award, presented by SPE National Membership Chairman Harry J. Krebs, includes a paid-up lifetime membership, a jeweled membership pin, and a walnut wall plaque. Johnson served as national membership vicechairman for Region VIII in 1964, as well as a vicechairman and director of the Southwest Texas Section (Corpus Christi). After being graduated from the U. of Oklahoma with a BS degree in petroleum engineering, Johnson joined Sun in 1956, working first as a production engineer in Rockport (Tex.) on the Seeligson Unit. He was transferred to Corpus Christi in 1966, and to Dallas as a staff drilling engineer in 1969. He assumed his present position early in 1970.

The five winning local sections in the SPE Membership Development Program were recognized at the luncheon. Section banners were presented by Membership Chairman Krebs of Long Beach Oil Development Co. to representatives of the South Plains (Lubbock, Tex.), Southwestern Alaska (Anchorage), East Texas (Tyler, Kilgore), Evangeline (Lafayette, La.), and Denver Petroleum sections. (See JPT, August, 1970, Page 962.)

Also recognized at the meeting was G. W. "Bill" Hoffman, White Shield Oil Co. in Tulsa, who was recognized for reaching the 50-member level. He will receive a jeweled membership pin and a wall barometer.

QUESTION MARKS DOT PETROLEUM ENGINEERING ENROLLMENT PICTURE

SUMMARY OF PETROLEUM ENGINEERING ENROLLMENTS, 1960-70

	Undergraduate	Graduate	Total
Fall, 1960	1,573	213	1,786
Fall, 1963	982	316	1,298
Fall, 1966	1,246	380	1,626
Fall, 1969	1,711	359	2,070
Fall, 1970	1,771	353	2,124

PETROLEUM ENGINEERING ENROLLMENTS—U.S. SCHOOLS

	1959-60, total	1960-61, total	1969-70, B.S.	1969-70, graduate	1970-71, B.S.	1970-71, graduate
Alabama, University of	15	9	10	2	14	4
California, University of, at Berkeley	25	29	9	8	13	8
Southern California, University of	85	78	28	46	40	49
Colorado School of Mines	116	101	124	9	97	18
Kansas, University of	69	37	22	16	19	15
Louisiana Polytechnic Institute	90	83	45	1	50	2
Louisiana State University	226	141	100	6	101	12
Southwestern Louisiana, University of	119	76	78	15	76	6
Marietta College	132	145	45		85	
Mississippi State University			67	1	63	0
Missouri-Rolla, University of	108	73	64	17	74	20
Montana College of Mineral Science and Technology	17	14	105	3	123	3
New Mexico Institute of Mining and Technology	24	28	32	2	33	2
Ohio State University	25	15	12	2	8	1
Oklahoma, University of	439	247	117	48	149	58
Pennsylvania State University	49	46	61	16	63	22
Pittsburgh, University of	50	33	31	9	20	5
Stanford University	34	26	9	24	5	23
Texas, University of, at Austin	319	494	136	49	148	44
Texas A. & I. University	159	146	100	0	102	1
Texas A. & M. University	200	135	155	12	144	12
Texas Tech. University	181	95	82		78	
Tulsa, University of	215	144	152	47	163	38
West Virginia University	30	31	24	4	21	6
Wyoming, University of			74	5	82	4
Minnesota, University of ¹	8	6				
North Dakota University ¹	9	4				
Houston, University of ²	142	96	20	7		
Oklahoma State University ²	170	120	9	10		

¹ Petroleum engineering curriculum dropped in early 1960's.

² Petroleum engineering curriculum dropped in 1970.

A decade makes a lot of difference—at least where petroleum engineering education is concerned. Despite the fact that faces have changed and the total number of students is smaller, petroleum engineering education appears to be on solid ground entering the 1970's.

JPT's 1970 survey of 24 U.S. schools shows undergraduate enrollment up for the seventh consecutive year, but graduate totals down for the second straight year. The total picture was an increase in enrollment to 2,124.

Undergraduate enrollment was 1,771 (up from 1,711 in 1969), and this figure does not indicate estimated enrollments for freshman and sophomore students at half of the schools. Best estimates are that the total PE undergraduate enrollment (including freshman and sophomore students) is about 2,450.

The 1968 draft rulings continue to have impact on the graduate enrollment picture. Graduate enrollment dipped to 353, down 6 from the 1969 report, but this figure is considered promising in view of the large graduate-level decrease experienced by other engineering disciplines. Nationwide estimates indicate that Fall, 1970, engineering graduate enrollments may be off by as much as 20 percent.

And there are the ever-present warning signals that tend to subdue optimism about the undergraduate situation. The JPT survey revealed that both the U. of Houston and Oklahoma State U., which had been attempting to keep some form of petroleum option program in operation, were pulling up stakes.

SOCIETY OF PETROLEUM ENGINEERS,
Dallas, Tex., April 12, 1971.

Mr. C. DREW STAHL,
*Department of Petroleum & Natural Gas, College of Earth and Mineral Sciences,
 The Pennsylvania State University, University Park, Pa.*

DEAR DREW: Thank you for your recent letter requesting information on the supply and demand for petroleum engineers.

Over the years, the Society's Education and Accreditation Committee has wrestled with the issue of how to obtain reliable statistics on this matter. To date, at least to my knowledge, no set of statistics has been developed.

For this reason, we attempt annually in the November or December issue of the magazine, to publish data regarding the supply factor with respect to petroleum engineers. Also, we annually publish a survey of salaries offered to recent graduates.

Perhaps the most helpful information can be found on page 1266 of the October 1970 issue of JPT and on page 1550 of the December 1970 issue of JPT.

Drew, I am sorry that I do not have the specific report that you requested, but hope that this information will suffice.

I have enclosed a copy of our Membership Directory for you.

Respectfully yours,

DAN K. ADAMSON,
Assistant Executive Secretary.

Dr. FALKIE. I don't think the problem is quite so bad as mining, but it is certainly not good. They could be working on problems of oil for conservation purposes, feasibility of underground disposal and storage if adequate funding were available for this type of research. So I recommend these remarks for reading, I am not going to say any more about them.

So, in conclusion, Senator, we in the mineral education and research business wholeheartedly support S. 635 because if it is administered correctly it will, first, be a step toward saving the mineral engineering schools which are a prime source of people and research for an industry basic to our way of life.

The mining school could be used as a force for third-party credibility along with industry and Government to help produce the leaders and technology and help solve the highly emotional problems of our day in an independent, objective way.

They have a tremendous specialized and applied research capability which can be used to the advantage of mankind in a mineral-dependent civilization.

Second, it can be a step toward solving the complex applied technological problems associated with health and safety, environmental control, conservation of mineral resources and meeting our production requirements.

Third, it finally begins to give recognition and support such as agriculture has had to a mineral industry as a basic industry in our country.

Thank you for giving me the opportunity to appear before you and present the statement.

Senator Moss. Well, we certainly appreciate your appearance, Dr. Falkie, and your very fine paper; and, as you emphasized at the very end, the mineral industry is a basic industry. We have awakened to the fact that we have allowed it to decline to a point where we must now do something specific to bring that industry the kind of support and attention and initiative that is needed to improve our technology and to apply that technology as it is developed by research.

Otherwise we will further decline in the supply of minerals and materials and fuels that we have until our whole way of life begins to suffer. That is not too far distant unless we do turn this corner. I agree with you; I think your presentation was excellent. We are pleased that you brought your colleague's presentation on the petroleum aspect, and we certainly appreciate having Dr. Elliott and Dr. Reid appear with you on this panel today. Thank you very much.

Senator Moss. As I announced, Professor Hassialis' statement is in the record. We will ask Dr. Edward Lear, dean of the School of Engineering at the University of Alabama, and Dr. J. Richard Lucas, of the College of Mining Engineering of the Virginia Polytechnic Institute, if those two gentlemen would come up to the table.

We are pleased to have you, and you have been with us in a long day of hearings. We look forward to having your addition to the record. We will ask Dr. Lear if he would proceed first.

STATEMENT OF DR. W. EDWARD LEAR, DEAN, SCHOOL OF ENGINEERING, UNIVERSITY OF ALABAMA

Dr. LEAR. Thank you, Senator Moss, and I know it has been a long day of hearings. I am going to attempt to summarize and omit wherever possible from the printed text I have submitted. I have one parenthetical insertion which I would like to make which is not in the printed material.

Senator Moss. You may so proceed, sir.

Dr. LEAR. I represent the University of Alabama which is in a State or region in which the economy is heavily influenced by the mineral industry. We are situated in the heart of the lower Appalachian region in the midst of a heavy concentration of industry related to minerals: Mining, extraction, production, fabrication, reclamation.

The College of Engineering at the University of Alabama first offered courses in engineering in 1837. It has been in the business of training mining engineers since 1884 and currently has the only program in mineral engineering in the eight-State Deep South region, the nearest others being at Virginia Polytechnic Institute, the University of Kentucky, and the University of Missouri.

So the region we serve is one which is very large and is rich in mineral resources and in manufacturing associated with minerals. It is at this juncture that I would like to digress from the printed text for a moment to express a concern which I have with the administration of S. 635, a point which has been touched on briefly before.

But our particular location and expertise, I think, would make us perhaps a logical choice, I am biased on this, but perhaps a logical choice for a regional center in the context of the bill. Under section 4, there is provision for States to get together and to develop regional centers.

I feel this philosophically is a wonderful idea, but I do have grave reservations about the inclination of States to follow through on this on their own initiative, to develop this kind of cooperative effort. I feel many States which now have no program or a marginal program connected to minerals will come up with matching funds of some kind so they can have an institute and one which will be marginally staffed and equipped.

I don't know what mechanism would be best to get around this, perhaps the Secretary of Interior might be empowered to see that

regional cooperation is done where it is appropriate, but I did want to express this particular concern with the administration of the bill.

Senator Moss. I appreciate your comment, and I recognize there is some problem toward local pride and desire to build up your own State institutions which might persuade some they should try to build their own school rather than cooperate in a regional area or regional institution that is already established and staffed.

So we will give that careful consideration as to how this might be administered to be wholly flexible and yet encourage the kind of regional cooperation you were referring to.

Dr. LEAR. I would like to say a word about the nature of the research that I see the centers are doing. Our main thrust in the College of Engineering at the University of Alabama would be toward the development of a strong research capability for tackling the real-world problems of the mineral industries of the region.

The character of this research we would define very clearly. It should obviously draw on the most sophisticated and modern tools that science and engineering have to offer for its base, but it would not be basic research in the sense of research for its own sake. It would be aimed at practical solutions to the myriad of problems which must be solved if the minerals needs of this Nation are to be met successfully and in a manner concomitant with keeping the quality of life at a high level.

If I may make a personal reference, I spent 2 years in 1963 and 1964 as head of the Engineering Section, now the Engineering Division of the National Science Foundation. I believe my memory is accurate when I say that we did not have during that time a single proposal to the Foundation for research which dealt either with mining or mineral production or with the societal problems associated with these endeavors.

This was no reflection at all of the desire or capability for faculties in mining and related engineering disciplines to do such research, but rather a recognition that NSF was not set up at that time to fund applied research of this type. There was a fair amount of research being supported in the physics of metals, and this has proved useful in our understanding of the properties of these materials and of the ways in which we can use them, but again this does not touch on the resource picture.

It is true that the National Science Foundation has now developed some programs which allow research on more applied problems, but the Foundation is not geared to support an attack on a single element of a societal problem such as the development of adequate mineral resources.

Since then the Foundation has developed the capability but it is not geared for an attack on a single element such as societal problems. So there wouldn't be a conflict there. The Bureau of Mines, too, has not had the resources to marshal in a concerted way the expertise available in the engineering and science faculties of appropriate universities for help in the solution of the problems which are its province.

It seems clear, then, that a unified effort of the type which would be provided by this bill is long overdue and that early enactment of S. 635 is indicated in the best interests of the Nation.

Let me be more specific, not in great detail but in broad outline, about how I would visualize the operation of a center of the type which is provided by the bill. I would envision banding together a group of 10 to 15 faculty members, drawn from a number of disciplines, involved in both teaching and research and supported by 20 to 30 graduate and undergraduate research assistants. This group would have close and continuous liaison with appropriate industry and with Federal and State Government agencies concerned with the mutual problems of mineral resources.

We currently have the nucleus for mounting this team approach to problem solving such as that I have described on our campus, as do many other institutions in other parts of the Nation. We offer a diversified mineral engineering program supported by a college with seven other accredited curriculums, including computer science and operations research and metallurgical, chemical, and civil engineering.

We have, in fact, recently combined the programs in civil and mineral engineering for the express purpose of bringing together faculty members having common interests in areas such as environmental quality (particularly air and water resources), structures, and soil and rock mechanics.

The university has a department of geology, and also located on our campus are the State geological survey, a U.S. Bureau of Mines Metallurgical Research Laboratory, and a U.S. Geological Survey water resources unit. The ties of our faculty with the mineral industries and with the Government agencies assisting and regulating these industries are excellent. Thus a large and diversified laboratory for the study of a wide variety of problems is available in this complex of university, industry, and government.

To see which mineral resource research problems we should most appropriately attack at the University of Alabama, we look to the characteristics of the region which we serve. The Southeast has a few very old highly industrialized areas, but widespread industrialization is low. This means that in most instances there is still time, through careful planning, and I believe the institution could be leaders in this, to develop the mineral resource industries of the region in such a manner as to protect the environment.

For example, largely because of the depth of weathering in a warm climate, our area has a wide variety of materials which must be surface mined: bauxite, brown iron ore, sedimentary kaolin, bentonite, scrap mica, tripoli, sand and gravel, manganese, and many others, including granite and limestone which are quarried and coal that can be strip mined.

Since our population density is about as low as our industrialization, we are in a good position to plan in advance the exploitation and beneficiation of these mineral deposits so as to minimize deleterious effects on the environment. Appropriate research directions indicated by these factors include long-range planning for mine land restoration and utilization; planning of public and private facilities in advance so as to interfere minimally with the recovery and processing of the mineral resources; planning of mineral industry development for the maximum utilization of our abundant surface and subsurface water supplies, and for protecting these supplies from pollution; and devising more efficient methods of surface mining and mine land restoration.

Other areas of research in which we have expertise include work on improved recovery and production methods on the region's resources of coal, the new resources of oil and natural gas, and the large low-grade potential source of uranium (Chattanooga shale).

The members of our faculty are of course not presently ignoring these problems. For example, our mineral engineering faculty members currently have modest contracts with the Bureau of Mines in the area of mine safety, and we are doing work on recycling of wastes of various kinds both in mineral engineering and in chemical engineering.

But there is no massive concerted effort directed at the solution of the multitude of problems connected with maintaining adequate mineral resources for this Nation. This requires funding of a sort that is simply not available and will not be available through the normal budgetary sources of universities or through the present channels of external support.

Inseparably connected with finding adequate solutions to our mineral resource problems is the provision of an adequate supply of trained manpower. The manpower situation is critical in the mineral industries at present and will continue to be so for the years immediately ahead, since appropriate training takes time. But it is my opinion that the development of the research centers which would be established under S. 635 will provide concurrently the long-term solution to both the mineral resource and related societal problems and the manpower shortage problem.

Research activity is intimately tied to the teaching function, and students will be attracted to a center of activity which has as its goal the solution of problems of such obvious relevance. Students today, as always, tend to go where the action is, and there is a synergistic effect in this type of effort which has been proved many times in the past.

The infusion of Federal money in large quantities following World War II into such areas as solid state physics and engineering, propulsion, nuclear energy, and many others with the accompanying popularity of the respective areas of engineering and physical science are well known. The same thing can happen and will happen in the area of mineral resources if the need is recognized by passage of this bill.

If this legislation is enacted, I think we can all point with great pride in the years ahead to having had a part in averting the national disaster of an inadequate supply of minerals.

Again, Mr. Chairman, and members of the committee, thank you so much for allowing me to appear before you today.

Senator Moss. Thank you very much, Dr. Lear, for your fine presentation and for pointing out to us the things that we must be concerned with in trying to make this program operate as we hope it will when this bill is passed.

Dr. Richard Lucas is head of the department of mining engineering at Virginia Polytechnic and I am glad to have you, Mr. Lucas.

STATEMENT OF DR. J. RICHARD LUCAS, HEAD, DEPARTMENT OF MINING ENGINEERING, VIRGINIA POLYTECHNIC INSTITUTE

Dr. LUCAS. Thank you very much. My name is J. Richard Lucas and I am from VPI.

I want to say that I am here to strongly support S. 635 to amend the Mining and Minerals Policy Act of 1970 and this bill hopefully

will strengthen mineral education and research and I want to underline that I think those two need to be taken together.

Mineral education and mineral research. Some have alluded to just research. It is broader than that, because without the people, the professionals, the mineral professionals we won't be going very far. Another thing I think needs to be emphasized here at the outset is that we can have men that will be temporarily supported but once the support dries up, if he is not a professional in the area, he won't continue a whole career year in and year out in this area.

I think we are talking about mineral professionals instead of just temporary researchers. I represent the fifth largest coal-producing State in the Nation, right in the middle of the Appalachians. And the Appalachians have had much publicity in them and we are very proud to say its most important natural resource, besides people, are the minerals that it has in the ground.

I certainly am in agreement with the National Academy studies that have been made in 1969, no one can differ and certainly everyone would need to agree with this very, very fine study. I want to say that our mineral engineering school should be vital in each of a number of fields and I am going to cite them as we see it in our area, mineral exploration, evaluation, development, production, beneficiation and mineral economics.

These areas have been typical mining, engineering traditional functions, and responsibilities. Areas of activities, if you will. Recently the Federal Government, the State government, local governments have come in and had a decided input into this profession in three significant major areas.

Certainly everyone has heard about the ecology and the environment. When we look at the mining problem, it is air, it is water, and it is land. In our great neighboring State of West Virginia serious discussion has been given to completely bank surface mining of coal. Unheard of a few years ago but this is a great challenge that our engineers have today.

Water and air—I happen to be chairman of our State committee on air pollution in the mineral industries and pollution in general and grappling with this problem all over the State of Virginia. Another area that government comes into has a tremendous impact and you in the committee are very much aware of this, mining health and safety.

They are landmark legislations, the Nonmetallics and Metallics Safety Act of 1966 and of course the historic Coal Mine Health and Safety Act of 1969. Government has had an impact and with one stroke of the pen thousands of jobs have been created in the government.

At the same time, gentlemen, thousands of jobs have been created in industry to balance this group. These jobs can't be filled. This is a national issue, as you know, many people have taken part in it and it hasn't been implemented by the legislative mandate that Congress has given it.

The reason is the men, the talent, isn't there. It reflects the very poor productivity that our mineral schools have had in the last 10 to 20 years. The third one we read about in our newspapers every day, in addition to mine health and safety, in Appalachian areas, certainly, is the energy shortage.

The sources for minerals and this is a topic we must solve or have to solve, it is a mineral problem because it comes from—the storehouse for energy is from the earth itself. These are all problems, some of them that have been traditional problems of the mineral engineers but some of them have recently been forced on us.

Another one that concerns me greatly that have been alluded to by Dr. Morgan, especially, and I was delighted to hear his presentation. In 1945 we were supreme in the world. We were way up here and many people were down below us. Today we have grown and increased in stature, world leadership, but I think in these 20 years since 1945, more than that, the world has come up and we haven't gone up as fast.

The foundation of international leadership, industrial leadership, world leadership has to be on a mineral foundation. Our mineral foundation relatively has not strengthened. It has grown weaker. This concerned me personally very much from an international point of view.

We no longer live in the Western Hemisphere alone, we live in a world economy. We are going to be traveling in this world round trip in a matter of hours. The country Dr. Morgan alluded to I studied very carefully and I have been amazed. This is a young economy, a young country. Steel leaders in our Nation today for the first time publicly are saying by the end of this decade Japan will produce more raw steel than the United States.

Russia, of course, is in between. But it is a foregone conclusion that in the middle of the seventies Japan will overcome Russia. This is a young industrial economy. Not a mature one such as we are. They have looked after their national interest.

The Japanese are concerned about mineral supply and mineral raw materials, it is a national policy. A conference of the Nation's leaders decide what is best for Japan. As a result they have been very effective throughout the world. Very courageous, believe me.

The first to go to the Congo, the first to go into Chile after nationalization of the copper and the first to go into many places. I think the example of how great these people are in the mineral field is when the Russians themselves signed the contract with the great Japanese people. They signed it to develop mineral-rich Siberia. I think it is a great tribute to their potential.

In my State of West Virginia we have some of the best coal, I think, in the world, and they have given our company the money to open these mines and signed a half billion dollar contract for this very valuable material for the next 30 years or so, and they have enough for the next 50.

Gentlemen, this isn't the U.S. reserves, this is owned by the Japanese. It is a foreign-owned mineral reserve in our own country. I am not saying this is wrong, but I am saying these people are looking after their national interests and we haven't been looking after our national interests of minerals.

Going a little further, I think we need to be very concerned in the free world, that is non-Communist world, source of strategic ground materials. They are rapidly becoming unreliable. Every day I read—I get papers from around the world, there is a new nationalization taking over government control of Africa, Zambia, the great Congo belt.

The situation you might think of in Africa as mineral rich, the rest of them have gone in this way and we see fantastic rapid development in

South America, Peru, and Chile. We have to look after our national interests and we do not have the resources to take advantage of a supply interruption.

As you know, we have had a copper strike a few years ago. We lost nearly \$1 billion in balance of payments because of this copper strike because of the import needs at that time. The dollar was under pressure at that time. So it is a reflection of how important this area is for the Nation's welfare.

There was some comparisons made with Russia and I want to allude to this. In my opinion the Russians are doing five to 10 times what we are in this particular field. In the field that I know so much more about than the others, in mining engineering, they are producing about five to 10 times as much.

We were very privileged to have men from behind the Iron Curtain come to our campus to study and I was very impressed with these men's background. These were very well trained professionals who knew their field well. If we had to compete on an even par with this type of talent, it should be recognized that they send their best talent to this country, we would be very hard pressed.

I have great respect for the training and perception and depth of knowledge that these people have. Now, we are producing in our country a little over 1,000 mining engineers and as you know the Health and Safety Mining Act alone would probably take that every year for 10 years.

So there is a great serious need for this. Another thing I want to stress in the recruitment of talent. It is one thing to recruit a man for a job that is white collar in nature, has a fine environment. In my own State in West Virginia we are mining 1,200 feet under the valley floor. Long-haul mining systems 500 feet long where dynamic failure of the roof is occurring constantly.

Men have to work in this environment. It isn't an easy environment to recruit talent in. This is something that we must recognize, that recruitment in this mineral field is a field that hands will get dirty, arms will be strengthened because of the work that has to be done in an environment that isn't the most desirable.

In a foreign environment, an environment that does not have the social amenities. I think all of these must be recognized and I want to compliment the individuals, Senator Allott and the rest that conceived this Mining and Minerals Policy Act with this amendment and I want to say that I was privileged to have added material to this original act of 1970 that appeared in the record, and I am really privileged and pleased to be able to be here today and add from my own personal experiences, because many have alluded to the most obvious that appeared in the report of the academies.

But this is a tough business, this is a competitive business, this is an international business and no nation for long can afford to be set in this particular activity if they aspire to maintain world leadership.

Before I leave, here is one part of the thing that I am very sensitive about and very concerned. That is halfway around the world we are fighting a war that 20 or 30 years ago we would have not even thought very much of. A second-rate power has been drawing us into a standstill.

Now, is this a test point of this great Nation who was born to lead, or is it testimony that we do have some cracks in its foundation and if we do, gentlemen, our mineral foundation of our industrial complex isn't as strong as it was relative to the world in 1945 and 1961.

I think the results show it. It is a privilege of being here before this committee. I had the privilege of being here before and I look forward to being here again. Because I devoted a whole career to this field, my father worked in the mines and his grandfather before him and as you know this has been a satisfying career for any man and I recommend it highly.

Thank you.

Senator Moss. Thank you, Dr. Lucas, for an eloquent, in-depth testimony, pointing out the urgency from a world point of view for improvement in our mining, engineering, and research fields and the need of regaining the preeminence we once had.

Japan is a great steel producer, and yet Japan just does not have the natural resources, and must import them, but nevertheless is forging ahead. As you indicate they may overtake the Russians fairly soon in production.

It doesn't seem possible, but there it is, and they are doing it by real devotion to the training of personnel and research and application of a great amount of energy and foresight. I do appreciate your testimony as I do that of Dr. Lear and we thank you for coming here today.

Do you have any comments, Senator?

Senator ALLOTT. No, I want to apologize to Dr. Lear and also the gentlemen who appeared on the panel just before this as just one of those things that we face all the time. But I appreciate very much your statement, Dr. Lucas, which I did have a chance to hear. I will read yours, Mr. Lear, and it has been very helpful.

Senator Moss. Thank you very much. Dr. Calhoun had to leave, so his paper has been submitted and will appear in the record in full. (The document follows:)

STATEMENT OF JOHN C. CALHOUN, JR., TEXAS A & M UNIVERSITY

My name is John C. Calhoun, Jr. I am employed by Texas A&M University as Vice President for Programs, Dean of Geosciences, and Director of the Sea Grant Program. My purpose in presenting this testimony is to register my endorsement of Senate Bill 635 in principle, but to offer comments on specific sections of the Bill which I think should be modified before it is enacted.

It is very timely that Congress give attention to the program authorized by S. 635. Research on problems of the underground environment and minerals produced from it has long been a neglected area in our nation. Educational programs pertaining to the development of underground resources and to protection of the underground environment have been supported largely by State tax dollars. As more glamorous programs have been initiated and have received federal support, competition for manpower has drained talent away from the fields devoted to underground resources.

There are two basic ways of exploring and developing our underground resources, including the production of minerals. One is through construction methods which allow man to enter the earth, generally known as mining. In the other approach, wells are drilled, allowing man to develop earth resources by transferring fluids into and out of the earth through these wells. Both of these methods are important. A program to develop research and education for focusing attention on problems of underground resources should not neglect either of these basic approaches.

In this respect, I believe the wording of S. 635 should be changed to make it clear that it is the intent of the Act to include all kinds of underground resource development and environmental protection whether done through wells or through traditional mining methods.

S. 635 envisions carrying out a program through Institutes established in each of the several states. This is a procedure analogous to that utilized in two other programs authorized in recent years. The Water Resources Research Act of 1964 established Institutes for carrying on research in water resources. I had the privilege of being the Acting Director to initiate that program in the Department of Interior. The Sea Grant College and Program Act of 1966, by contrast, authorizes a program to build university capabilities for developing the field of marine resources, and authorizes Sea Grant Colleges, but does not indicate the particular category of universities at which the program will be established. I am Director of an Institutional Award at Texas A&M under the Sea Grant Program.

Having had familiarity with both of these other programs, I raise a question as to the advisability of the limitations of Section 4 of S. 635, which spells out the priority categories for universities within a state that would be eligible for authorized Institutes under this legislation. It seems to me that it would be better to permit the Secretary of Interior to use his administrative procedures to determine at what university within a state an Institute should be established. This might, in some cases, be a private institution rather than a public institution, or it might be a state university rather than a land-grant institution.

My general point is that effective Institutes are much more likely to be brought into being if the choice of universities at which the Institutes are located is made by administrative determination after the legislation has come into being, so that the administrator can assess the relative merits of university programs and the probabilities of achieving success.

S. 635 could also be improved, in my opinion, if the program included advisory services as well as research and training centers. I recommend that the last line of Section 3 be modified to read "the establishment of an appropriate research, training, and advisory service center in each state."

I make this observation following my experience with both the Water Resources Research Act and the Sea Grant College and Program Act. The latter of these does provide for a program of advisory services. This has enabled the universities who carry out Sea Grant Program work to establish close working liaison with government representatives, industrial representatives, and the general public. Effective feedback from users to the research and training program can be achieved in no other way. The existence of an advisory service element to the program insures a greater likelihood that the benefits of research will be translated into usable and useful products by industry and/or members of the general public. The lack of an advisory service program is felt very keenly by those engaged in the Water Resources Research Institutes and there is now legislation before Congress to amend that legislation to add this provision. In my opinion, it would be a mistake to initiate a program for Institutes to advance the development of the underground environment without including a provision for advisory services.

In summary, I think it quite appropriate that Congress pass S. 635 and I encourage Congress to do so. The Water Resources Research Act of 1964 provided a set of Institutes for dealing with water resources. The Sea Grant Program Act established a similar program for attention to marine resources. The passage of S. 635 will add a set of Institutes dealing with the underground environment. If a set of Institutes were authorized for problems of the atmospheric environment, the nation then would have a series of Institutes dealing with the total physical environment of the earth.

I encourage Congressional action toward that end.

Senator Moss. I would like to have Dr. Lacy, Dr. Hines, Mr. Haley, and Dr. Pentecost all come to the table now when we complete these. I think that will complete our record. Unless I have overlooked somebody, if I have they will not be precluded from testifying. But I think these gentlemen can round out what we had scheduled for today.

Would you proceed, then, in that order. Dr. Lacy, executive head of the Department of Mining & Geological Engineering of the University of Arizona.

STATEMENT OF DR. WILLARD C. LACY, EXECUTIVE HEAD, DEPARTMENT OF MINING & GEOLOGICAL ENGINEERING, UNIVERSITY OF ARIZONA

Dr. LACY. I am Dr. Lacy from the College of Mines of the University of Arizona, presently chairman of the Minerals Division of the American Society of Engineering Educators, and I carry their support of Senate bill 635. I am chairman of the Mining & Explorations Division of the American Society of Mining & Metallurgical Engineers and in talking to my colleagues there I find that they are almost to a man strongly behind the Senate bill.

I am not going to follow the text which you have in hand. I come from the copper capital of the world in Tucson, Ariz., and I voice the concern of all the people in this area that we need to do something and do it quickly about our mining industry. We are on a collision course with crisis in connection with all of our mineral resources of this country. We have an inadequate technology with a declining economic position of the industry, insufficient manpower, and a deteriorating academic source of people and we have competition for land and increasing problems of waste disposal.

I speak primarily for mining engineering at the present time but I have incorporated a statement by a colleague of mine in extractive metallurgy which I have affixed to my statement, and I hope this will be incorporated in the record.

Senator Moss. It will go into the record in full.

Dr. LACY. There has been discussion of the number of graduates who go into mining engineering. I think we ought to look at this in terms of this figure you have received, approximately 25 percent are foreign students and only 50 percent of those who remain are actively being involved in U.S. mining.

So instead of 125 or so U.S. graduates we are talking in terms of an effective production of about 50 mining engineers per year. This puts a slightly different point of view on the numbers game. Likewise in trying to make an evaluation of the requirements of the industry I come up with a figure between the requirements of coal, of hard minerals, nonmetallics, of construction, of the requirements of government. We have a present requirement of approximately 500 mining engineers per year, we are off by an order of magnitude.

One other point I want to make is that in open pit operations and in strip mining these are essentially—this is essentially materials excavation and transfer. We can use civil engineers or mechanical engineers to perform many of the functions of the mining engineers in these areas.

However, in the copper industry in the Southwest the new finds that are being made are from 3,000 to 5,000 feet in depth. These will entail the solution of complex problems of rock excavation and support and this is part of the unique training of a mining engineer.

As we go to deeper mines we will not be able to make these substitutions of people from other engineering fields. I feel that the Senate bill 635 will enable us to reverse the spiral into crisis. I think the best place to start is in the mineral engineering schools and I think this is where it is starting.

I think there are certain things it will enable us to do. It will enable us to equalize tuition for in-State and out-of-State people. It will enable us to increase our faculty, which is a very minimal faculty and allow us to bring greater expertise to bear on the problems of the mining industry.

It will supply funds for graduate and postdoctoral research. Whereas agriculture has their experiment stations I think mineral engineers require full-scale experimental mines and processing plants and perhaps developing joint efforts between universities, industry, and the Government in the operation of these experimental projects.

Research funds that are funneled through mineral engineering department can bring in a variety of expertise to other fields to bear on practical mining problems. Supply of funds for student recruitment are desperately needed. We have plenty of statistics to support that.

One other factor that has not been brought out, the agriculture people carry on extensions where they take the knowledge that is developed in the agricultural area out to the field to take it to the people who work in that area.

I think that in mining we need to do the same thing. We are developing new mines on the Indian reservation where we have no technology at any level capable of supporting these mines. I think we need to take this training out to the Indian reservations and we need to take it out to the small towns that are supporting the mines.

I appreciate the opportunity to be here today and I give my full support and the support of the institution and the organizations I represent to the full support of the bill. Thank you, sir.

Senator MOSS. Thank you, Dr. Lacy, for your fine statement. I have noted the charts and graphs that you have attached, which will be very helpful in our record. I am glad to have you come and make this appearance before our committee. We appreciate that very much.

Any comments or questions?

Senator ALLOTT. No, I think the graphs with respect to demand and supply are very helpful. One thing I would like to ask you is am I under the wrong impression that while our supply and training of engineers in these areas has been at a very low level, that actually the engineers that we have been educating in this country have to a great extent been drained off to mining propositions and mining industries in other countries?

Dr. LACY. That is right, we end up with only about half of our trained people being effective in the mining industry in our own country. They have spun off to other areas where the training of the mining engineer is attractive, but many of them have gone foreign.

Senator ALLOTT. Thank you.

(Dr. Lacy's prepared statement follows:)

STATEMENT OF WILLARD C. LACY, HEAD, DEPARTMENT OF MINING AND GEOLOGICAL ENGINEERING, UNIVERSITY OF ARIZONA; CHAIRMAN, MINERALS ENGINEERING DIVISION, ASEE; CHAIRMAN, MINING AND EXPLORATION DIVISION, AIME

There are many ways to play the numbers game in terms of establishing shortages or excesses to prove a need, and we often manage to overshoot real needs. However, it is a responsibility of those in the academic area to predict trends, to alter curricula to anticipate society's needs, and to stimulate recruitment into those areas of predicted shortages.

I need not recite the importance of our mineral and fuel resources, growing metal requirements, nor cite in detail the statistics of shrinking enrollments and disappearance of departments in mineral engineering. This is reflected in the 1969 report on Mineral Science and Technology by the National Academy of Science (Figure 1).

There are at the present time 17 accredited mining engineering curricula in the United States (including Alaska) that turn out approximately 100-125 graduates each year. Ten of these schools are in serious danger of having the mining engineering options eliminated. Of the graduates approximately 25% are foreign students, and only about half of the remainder enter the mining industry as operating mining engineers and mine managers. This leaves an effective output of mining engineers of about 40 to 50 per year.

In the coal industry alone, in order to compensate for retirements and new mining operations being brought on stream, requirements are approximately 250 men per year. In the hard metals industry requirements as replacements and staffing of new mining operations are approximately 100 to 150 men per year. The non-metallic mineral industry could utilize some 50 or more engineers a year, and government (State and Federal) health and safety regulation could, on a regular basis, easily absorb another 50. The construction industry with increasing tunnel and underground installations might utilize another 30 to 50. Thus, we come up with annual requirements somewhere between 480 and 550 mining engineers in order to have a viable mineral industry. This would call for (on a 60% effective utilization basis) of 800 to 900 graduates a year, or total enrollments in mining engineering of about 4,000—an order of magnitude greater than at present.

We face an economic squeeze between rising costs and relative decline in metal values (Figure 2), of declining grade of ores (Figure 3), increased depth of ore (Table 1), and increasing power requirements to extract the metals (Figure 3), of increased competition for land and increased land requirements (Figure 4), of tight money and vastly increased capital requirements, (Figure 5). We face political and social attacks in terms of environmental disturbance, and hazardous working conditions. We face manpower problems in the need for increased technical skill and technological research, and the gradual disappearance of mineral engineering schools.

In open pit operations, where problems are essentially that of materials excavation and transfer, civil and mechanical engineers can be utilized to perform many of the functions of the mining engineer. However, new finds in the copper industry in the Southwest, for example as shown in Table 1, are being made at depths in excess of 5,000 feet and will entail solution of complex rock excavation and support problems that are unique in the training of the mining engineer. These same problems of prediction and control of rock behaviour are inherent in the coal industry.

Aiding the mineral engineering schools would appear to be the place to start to reverse the spiral into crisis—this is where engineering capability and technological break-throughs can be initiated. Most mineral engineering schools are caught in a tight budget squeeze. First they are confined largely to low-population states and out-of-state students are discouraged by high tuition charges from entering the field. Low enrollments are generally able to justify only two or three faculty members who must teach the entire spectrum of courses and have little time for developing specialties or for engineering research. Graduate students are without financial or research support. Capital budgets are limited to a few thousand dollars a year for inadequate laboratory equipment, when major field experimentation is called for.

I feel that Senate Bill S-635 would enable the mineral engineering schools to take the following steps:

(1) Equalize tuition rates for out-of-state students who wish to enter mineral engineering.

(2) Increase numbers of faculty in mineral engineering departments to bring greater expertise to bear upon mining problems—a general upgrading of faculty.

(3) Supply funds for doctoral and post-doctoral research directed toward development of new technology under field conditions. Where agriculture has experiment stations, mineral engineering requires full-scale experimental mines and processing plants—perhaps joint efforts between the universities, industry and government could be instigated.

(4) Research funds funnelled through mineral engineering departments could draw in expertise from other engineering and science areas to solve realistic problems of mineral resource technology.

(5) Supply funds for films, speakers, and TV programs that tell the story of mineral engineering. Our present supply of engineers come largely from those limited areas where the story is being told and the challenge of the industry to meet society's present and future needs is being presented.

(6) Establish extension branches of the university at the localities of new mining developments, on the Indian Reservations and small population centers, to train technical capability for safe and efficient operation. The needs for Arizona's occupational requirements for engineers, technologists, technicians and labor are reflected in Figure 6 a to f, as reported by the Arizona Employment Security Commission.

TABLE 1

DEPTHS OF SOME OF THE NEW COPPER-MOLYBDENUM DISCOVERIES IN WESTERN UNITED STATES

Location:	Depth in feet
Twin Buttes, Ariz.....	500 to +3,000
Sierrita, Ariz.....	to +3,000
Kalamazoo, Ariz.....	3,000 to 5,000
Red Mountain, Ariz.....	3,400 to 5,200
Copper Creek, Ariz.....	2,000 to +3,000
Miami East, Ariz.....	2,000 to 5,000
Lakeshore, Ariz.....	to +3,000
Henderson, Colo.....	2,700 to +5,000

MINERAL SCIENCE AND TECHNOLOGY

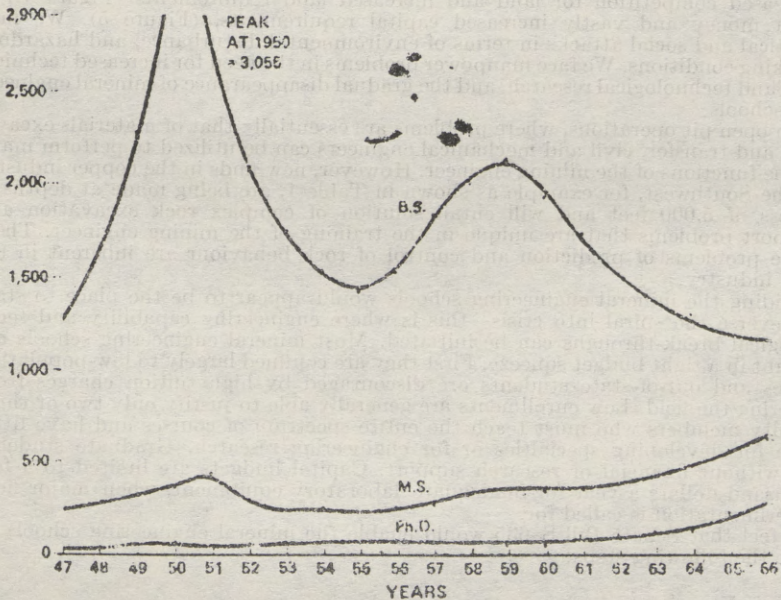


FIGURE 1 Degrees in mineral science and technology granted, 1947-1966.

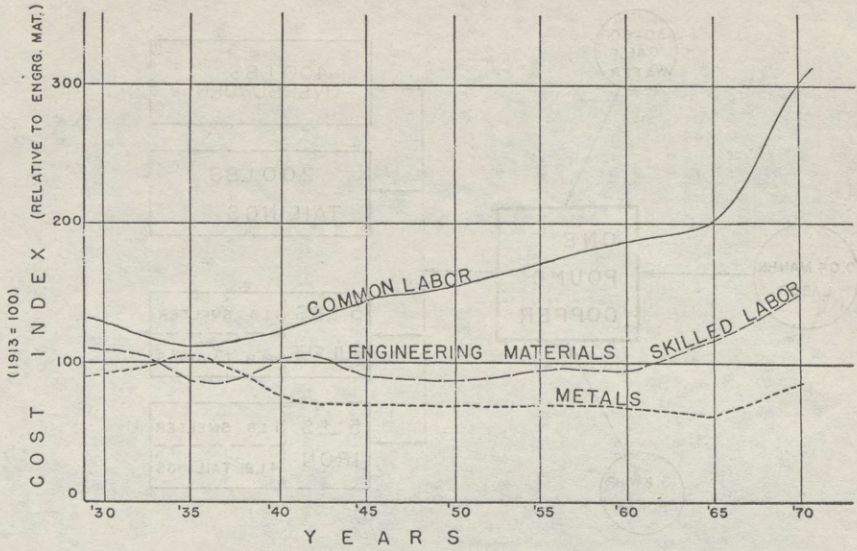


Figure 2: Value of metals relative to engineering materials and labor, 1930 to 1970.

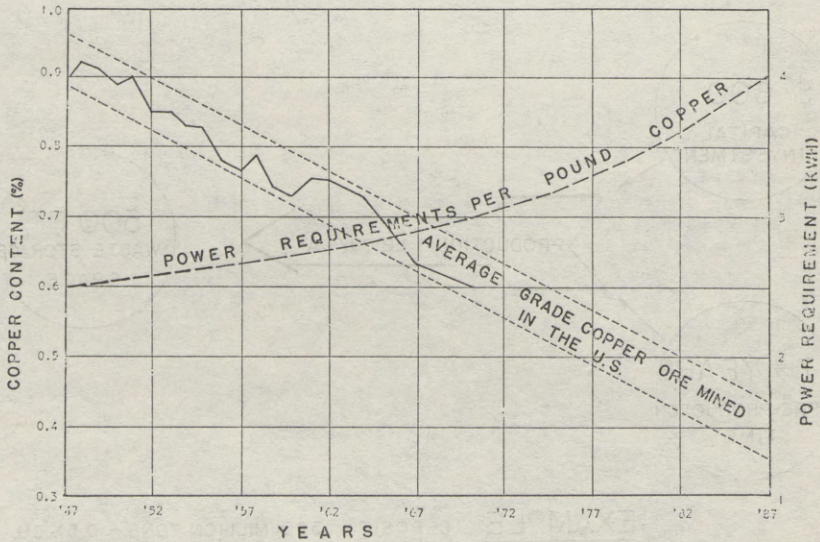


Figure 3: Decline in grade of copper ore mined in the United States, 1947 to 1987, and increase in power requirements per pound of copper produced.

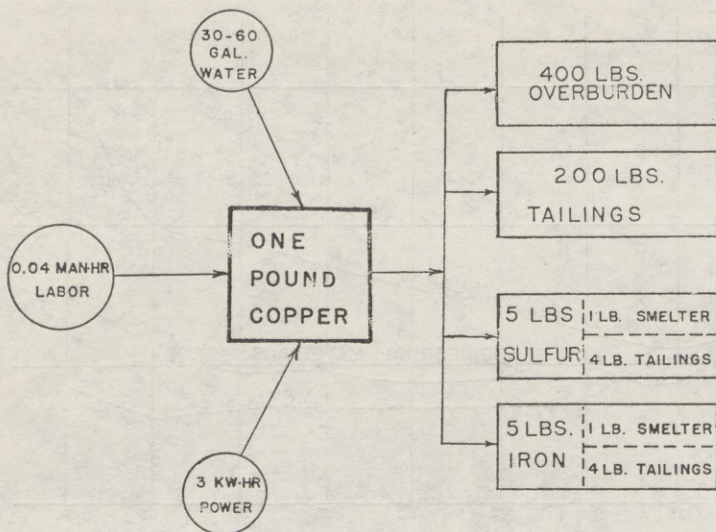
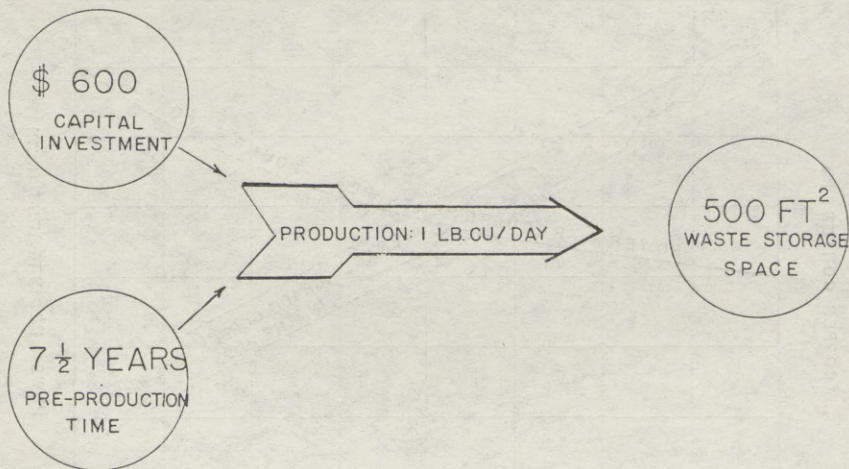


FIGURE 4: PROBLEMS OF CONSERVATION AND WASTE MANAGEMENT IN COPPER PRODUCTION



EXAMPLE: DEPOSIT: 300 MILLION TONS— 0.5% CU.
 PROD: 40,000 TONS PER DAY
 CAP INVEST: \$ 240 MILLION
 COST DISCOVERY: \$ 60 MILLION
 WASTE STORAGE: 4,000 ACRES

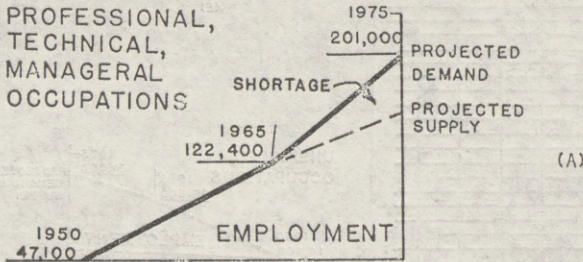
FIGURE 5: REQUIREMENTS IN TIME, CAPITAL AND AUXILLIARY SPACE FOR COPPER PRODUCTION.

FIGURE 6

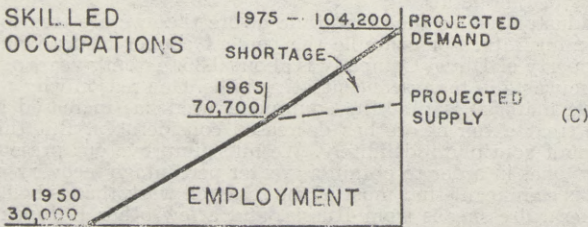
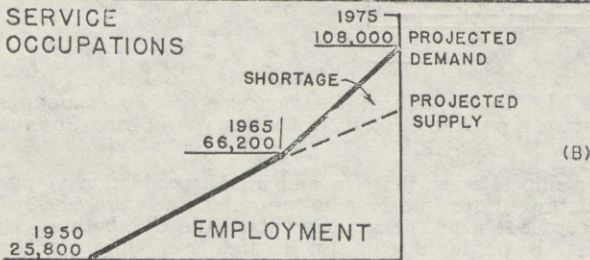
ARIZONA'S OCCUPATIONAL OUTLOOK TO 1975

(AFTER: ARIZONA EMPLOYMENT SECURITY COMM.)

ENGINEERS & 4-YEAR TECHNOLOGISTS

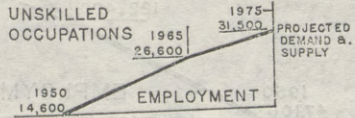
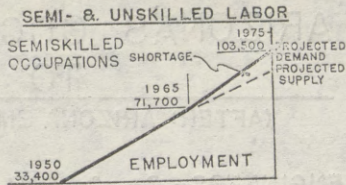


2-YEAR TECHNOLOGISTS & TECHNICIANS



(D)

OCCUPATION	DECLINE IN EMPLOYMENT	SLUG GROWTH	AVERAGE GROWTH	RAPID GROWTH
	0 - 40%	40 - 60%	60% +	
Accountants and Auditors				
Air Conditioning Mechanics				
Auto Mechanics				
Bookkeepers				
Business Machine Repairmen				
Cashiers				
Chemists				
Clerk Typists				
Data Processing Equipment Operators				
Draftsmen				
Economists				
Electricians and Electrical Repairmen				
Electronic Mechanics				
Electronic Technicians				
Engineering and Science Technicians				
Engineers				
Instrument Makers and Repairmen				
Mechanists				
Maintenance Mechanics				
Purchasing Agents and Buyers				
Office Machine Operators				
Office Machine Servicemen				
Plumbers and Pipefitters				
Sheet Metal Workers				
Shipping and Receiving Clerks				
Surveyors				
Television and Radio Repairmen				
Truck Drivers, Heavy				
Truck Drivers, Light				
Welders				
Writers and Editors				



STATEMENT OF THOMAS M. MORRIS, HEAD, DEPARTMENT OF METALLURGICAL ENGINEERING, UNIVERSITY OF ARIZONA; PAST CHAIRMAN OF THE COUNCIL OF EDUCATION, AIME

The processes used in minerals beneficiation and in the production of pure metals will have to be improved upon in the near future, and new processes will have to be developed in order to meet the requirements of the U.S. both as concerns tonnage of metals to be produced, and also the tighter specifications that will be imposed on purity of the metals.

We in the minerals industry realize that the grade of ore that we are treating is decreasing at an alarming rate. For example the percent copper in ore being mined at the Sierrita property of Duval Company is about 0.35. Twenty years ago this was very close to the waste in many concentrating mills. One reason why we can treat such low grade material is that the equipment used has increased in size so that the cost to treat a ton of ore has decreased considerably. But this compensating factor cannot continue indefinitely. We must improve our present operation or develop new ones in order to obtain a greater percentage recovery of the valuable mineral. It is significant that most of the research work that is being done in the field of mineral dressing is from Russia, and a few other European countries.

Extractive metallurgy is faced with the problem of increasing the production of metals, and at the same time producing purer metals than we have had to do in the past. This means that we must improve our present processes, and if that does not do the job we must devise new methods. For example we know that certain impurities in copper, such as 0.0005% selenium may cause copper to break when it is drawn into very fine wire.

Many of the improvements in present processes, and the development of new methods have been done by metallurgical engineers in foreign countries such as Australia, England, Sweden, Finland, Japan, and Russia.

In order for the United States to satisfy its future need of metals we should do the following:

1. Publicize the need for young people to enter the mineral and metals producing industry.
2. Encourage schools that are active in mineral dressing and extractive metallurgy to develop experimental stations at which new processes can be evolved.
3. Encourage closer liaison among colleges, the U.S. Bureau of Mines and industry.

4. Establish scholarships, fellowships and grants to help qualified students to study for careers in the mineral industry.

Steps 2 and 4 could come into being because of the financial aid from S. 635.

Senator Moss. Now, Dr. Heins, who is professor of mineral engineering, University of Wisconsin.

STATEMENT OF DR. ROBERT W. HEINS, PROFESSOR, DEPARTMENT OF METALLURGY AND MINING ENGINEERING, UNIVERSITY OF WISCONSIN

Dr. HEINS. Thank you. I am Robert Heins, professor of mineral engineering, University of Wisconsin, Madison. This statement is intended to endorse the concepts embodied in S. 635. Most of the ideas and thoughts I have in this statement have been expressed a number of times by my colleagues and since this will appear in its entirety as I have presented it here, I would just like to summarize by saying that we at Wisconsin believe that the solution to the problem of educated manpower needs for implementing the Mining and Minerals Policy Act toward the strengthening of the production and utilization of our mineral resources appears best to be achieved through the establishment of institutes or centers as proposed in S. 635.

This also seems to be the best way of preserving and strengthening the mining and mineral engineering departments which still exist at universities which now only partially supply the demand for trained manpower in the mineral industry.

I urge this committee report the bill favorably and seek its passage.

Senator Moss. Thank you very much, Dr. Heins. Your full statement is in the record. We do appreciate your endorsement from the University of Wisconsin. We have witnesses from all over the United States and they agree so thoroughly that it is somewhat remarkable.

Usually we get some areas of disagreement but today we seem all to be right on the bill that Senator Allott drafted and the rest of us sponsored, it seems to have struck a responsive chord.

(The prepared statement of Dr. Heins follows:)

STATEMENT OF ROBERT W. HEINS, PROFESSOR OF MINERAL ENGINEERING, UNIVERSITY OF WISCONSIN, MADISON

This statement is intended to endorse the concepts embodied in S635. Implementation of the Mining and Mineral Policy Act of 1970, Public Law 91-631 requires that it be amended or supplemented in ways such as those proposed in S635.

The S635 bill is endorsed for two major reasons:

1. There is a vital national need for strengthening the production and utilization of our mineral resources from both virgin and recyclable sources.
2. Educated manpower is a key factor in strengthening our mineral resource programs and educational institutions are the main source of the needed manpower.

These reasons are developed very completely in the report of the National Academy of Sciences Committee on Mineral Science and Technology. Supporting data and arguments presented in that report need not be repeated here. Rather testimony relating to its implications to the State and University of Wisconsin is offered.

The manpower problem at the University of Wisconsin is similar to the national trend. Enrollment in mining and mineral engineering and process metallurgy undergraduate academic programs has declined steadily since World War II except for a second peak which developed in 1957-58. In our case, the number has decreased from a peak of 66 in mining engineering and 94 in metallurgical engineering to a low of 20 in mining and 51 in metallurgical engineering during the

last several years. Costs per student rise to unacceptable high levels with low enrollments so that many universities have discontinued their mining and mineral engineering departments. This situation is presently being reviewed in the higher education system of the State of Wisconsin because of low enrollment at the University of Wisconsin-Madison and Platteville State University. Financial support of educational programs and recruitment which will stimulate increased enrollment are badly needed. Increased enrollment at the undergraduate level is vital to supply the manpower for direct employment in mineral industries after the B.S. degree and to provide the graduate student body necessary to carry our research programs required for improved use of our mineral resources. Financial support of these departments which still offer degrees in this field is the most direct route to resolving the manpower problem. Such support should include the establishment of a "Mining, Minerals, and Related Environmental Research Institute, Center or Equivalent Agency" as set forth in S635.

The institute or center concept is endorsed for several reasons. First of all it would serve as a focal point of expertise in mineral resource and related environmental concerns of the State. Some of the staff could serve a dual role as professors in the mining and mineral engineering department and as public servants to the institute. Second, the presence of the institute would provide a facility for part of the academic instructional and research programs. Because of its visibility, it would also assist in recruiting. It could provide practical training in mining and mineral engineering areas of concern to the various public and private employers. Students could work on research problems carried on for State and Federal agencies such as the U.S. Bureau of Mines, EPA, HEW, the State of Wisconsin Department of Natural Resources; and for private industry. Furthermore, the institute or center would provide assistance to legislators, citizens' groups and others involved in mining and process metallurgy problems. At present, the State of Wisconsin has no such point of reference for expertise other than faculty members of the Department of Metallurgical and Mineral Engineering at the University of Wisconsin-Madison. These faculty are so occupied with teaching duties that they can function in an advisory capacity in only a limited way. Adequate assistance to the State in this field is thus lacking.

All projections for mineral commodities show a substantial increase in utilization during the next several decades. One largely untapped but hopefully growing source of metals is the recycling program being researched at a number of research facilities and universities. However, a major resource problem has recently emerged on a world wide basis. A new nationalism is evident in many countries which are now sources of the virgin ores. Many deposits have been nationalized outright or the host countries have increased production taxes on the mining properties. In some cases these countries have increased their interest in these mining ventures to a controlling interest. The net result is that the United States must place less emphasis on these foreign sources and more on its own, particularly in case of a national emergency.

There are many deposits within the United States which contain very small percentages of the desired metal or mineral and they cannot currently be mined and processed profitably. With the center or institute concept problems of mining, mineral processing and extractive metallurgy can be studied and solved. Eventually these solutions can lead to the economic use of these low grade resources both in the state and nation. It is this fact that bears directly on the concepts embodied in bill S635.

In summary then, the solution to the problem of educated manpower needs for implementing the Mining and Mineral Policy Act toward strengthening the production and utilization of our mineral resources appears to be best achieved through the establishment of the institutes or centers as proposed in S635. This also seems to be the best way of preserving and strengthening the mining and mineral engineering departments which still exist at universities and which now only partially supply the demand for trained manpower in the mineral industry. I urge that the committee report this bill favorably.

Senator Moss. Ted Haley, associate professor of mining, and director of the mining option of civil engineering, University of Kentucky.

**STATEMENT OF TED D. HALEY, ASSOCIATE PROFESSOR OF MINING
ENGINEERING, UNIVERSITY OF KENTUCKY**

Mr. HALEY. I am Ted Haley, director of the mining option of civil engineering. I do not have a written statement and I will be verbal only very brief.

Senator Moss. Let me invite you, if you care to submit a written statement, please mail it in to us and we will put it in the record.

Mr. HALEY. My physical presence here is simply to lend emphasis to the strong support which the University of Kentucky and many or most of the management people give to S. 635. It is our opinion that this proposal and concept is flexible enough and productive enough to take care of the needs of the Nation and the peculiar requirements of any State or region.

Therefore, as I say, I will repeat once again, Kentucky lends its full support in concept to this bill. Any details that we have we are writing our Kentucky delegation on some very minor details. Thank you.

Senator Moss. Thank you very much, we are glad to have that endorsement and support from Kentucky and we will look forward to hearing from your colleagues in getting their help as we present the bill on the floor of the Senate.

Senator ALLOTT. Just one thing, Mr. Haley, this is a very busy place and I think it would be very helpful for Senator Moss, the chairman, and myself if when you have some suggestions you would send us copies of them directly so as we proceed with the consideration of the bill we will have them in hand.

Mr. HALEY. We will do that, thank you.

Senator Moss. Dr. Joseph L. Pentecost, who testified for the National Institute of Ceramic Engineers, from Columbus, Ohio. I am very pleased to have you, Dr. Pentecost, and we haven't given much attention to the ceramic side of this discussion, so we are most pleased to have you appear before us now.

**STATEMENT OF DR. JOSEPH L. PENTECOST, TESTIFYING FOR THE
NATIONAL INSTITUTE OF CERAMIC ENGINEERS, COLUMBUS, OHIO**

Dr. PENTECOST. Thank you very much. It is a pleasure to be here today to represent one segment of nonmetallic materials area that I feel is positively influenced by this bill. I am testifying in behalf of the National Institute of Ceramic Engineers which represents about 1,700 active ceramic engineers in this country.

The National Institute of Ceramic Engineers is closely associated with the American Ceramic Society, our technical society, which currently has about 6,800 individual members. The National Institute of Ceramic Engineers is also an associate society in the Engineers Joint Council.

Our industry represents about \$10 to \$15 billion in annual product value. This figure represents the values of the ceramic products alone,

not the value of the entire automobile when we are considering only the spark plug insulators. Some of the major segments of this industry include:

	<i>Millions</i>
Abrasives.....	600
Plumbing fixtures.....	200
Dinnerware and pottery.....	200
Building products (portland cement, lime, gypsum, brick drain tile, wall and floor tile).....	3, 000
Glass products (flat glass, containers, fiberglass).....	3, 500
Porcelain enamel and ceramic coating (appliance parts, signs, plumbing fixtures).....	300
Electronic and technical ceramics.....	700
Single crystals and optical materials.....	20
Carbon and graphite specialties.....	100
Refractories (furnace linings, temperature-resistant materials).....	700

The ceramic industry is an important one, increasingly complex and technology oriented. A brick may not appear to require engineering, but consider that clay is mined, beneficiated formed to a precise shape, dried, fired to over 2,000° F., and marketed profitably for less than 2 cents a pound, that is a technological achievement in today's economy.

They may be even more important to us in the future as we try to make substitutions of these materials. I am going to abbreviate my statement here somewhat in view of the fact that you have the statement in its entirety. I have pointed out how our manpower needs in this area are serious. We have a need for at least three times the number of ceramic engineers that are currently being graduated. It is similar to the situation that exists in mining engineering.

The National Academy of Sciences in 1969 prepared a specific report on nonmetallic materials which I commend to your attention and this I have submitted with a copy of my testimony for the record in case anyone else has not submitted it and it is accurate and we feel positively representing the situation in our industry to date.

Senator Moss. We are pleased to have that, and it is incorporated in the record by reference.

(The document referred to above was retained in the committee files.)

Dr. PENTECOST. Very good. Several other points I would like to underline. In 1966 the bachelors granted in ceramic engineering in the United States was 162, masters 56, and Ph. D.'s 52. By contrast, for 1968 the annual rate in Japan was 420 for bachelors, 100 for masters, and 20 doctorates. This ratios out on the basis of population to four and a half times as many bachelors' degrees, three times as many master's degrees, and approximately an equal number of Ph. D.'s in the ceramic science and engineering area.

This may explain some of the impact that foreign competition is having on certain segments of our ceramic industry today. We are quite concerned also with the research in our ceramic industry that is supporting this. This has been brought out in certain of the references which I have cited here.

It affects large segments of our technological economy to date. One of the quotations I would like to emphasize here is the semiconductor maker today, who is quite frequently paying several times the price for the ceramic package than it costs him to make the chip, yet the silicon chip requires much more processing and more more complex

technology than the ceramic package and he asked, why does it cost this?

One of the reasons is that he has been subsidized by a great deal of Government research and development in the past and the ceramics industry that is trying to supply that package for him has not been. I would particularly refer you to several quotations from this report. I would like to read one of them particularly:

The non-metallic materials is a field in which very large fraction of the total research in the country has been conducted and financed by major industrial organizations. Here is a startling example, in the glass industry each of the major companies performs several times more research than the total amount of university research on glass in the country.

Likewise in other fields of interest to this panel, whether in research or in factory or in making synthetic diamonds, the Federal university support of research has been very small. This feature of research and development is unique compared to several other parts of modern materials technology.

This underlines the basic need for additional basic research in the area of nonmetallic materials. We feel that this present bill speaks to this area particularly, it benefits us both in the area of increased manpower production and also in support of our industry and we would commend and heartily support S. 635 as a direct benefit to our segment of the industry.

Thank you.

Senator Moss. Thank you very much for that statement and for the very extensive paper that you prepared, which will be part of the record. We do appreciate your coming here to testify and calling to our attention the needs of the ceramic area of mineral development.

Certainly it is as important as any other segment. I am glad you were here and testified for the Ceramic Institute today. Now, I have called all of the witnesses. Is there anyone who was left out who expected to testify?

Apparently not. The record is going to remain open for 30 days. If because of anything you heard the other witnesses say and you would like to comment or because of something additional you think should be in the record that is not in there, and it is applicable and would be helpful to us we solicit your sending further information in writing to us.

Just send it to the committee here and it will be inserted in the record. The record is important because out of that we determine what we are going to do as we mark up the bill, and we want to have all points of view before us. As I commented earlier, it seems to me that we have something here that everybody agrees to so we ought to start off running with this one. We hope we will.

I particularly compliment my colleague, Senator Allott, who took the lead last year in getting a statement of mineral policy in bill form and now this proposal will add an additional section providing for training and educating specialists in the field and getting research done in this whole field of minerals. The whole area has been ignored for a number of years.

As I say, I appreciate the attention you have given, you have stayed with us for a long day and we have built a very good record. Senator Allott may have a word he would like to say.

Senator ALLOTT. I just wanted to say, Mr. Chairman, I am appreciative of the fact that you have held these hearings at a very early and timely point. I am only sorry that all of the gentlemen who have

been here today are not present for me to express my appreciation for their remarks.

There have been suggestions made here today and you said that you have suggestions you would like to make with respect to the bill, and we welcome them. We are in a sense pioneering here in a new area. Other similar things have been done in the Government, but we want to get this off on the right foot. We want a sound and workable bill when we get it passed.

I want to express my appreciation particularly to you four gentlemen for your testimony. I would like to ask just one question.

I was informed the other day that the basic method of making plate glass, and that is in your area, is derived from English patterns. Is that correct?

Dr. PENTECOST. Yes, sir, this is a process that is revolutionizing the making of plate glass today.

Senator ALLOTT. And we are paying royalties to Great Britain for the making of flat glass in this country?

Dr. PENTECOST. Yes, sir; this is the case with many of the other processes that are being generated from outside of this country.

Senator ALLOTT. Touching on another facet of that same problem, I was informed at that time by this gentleman, and I think he knew what he was talking about, that the contract by which they license companies in this country to use the process also requires that any patent improvements go to the benefit of the parent company? Can you confirm this?

Dr. PENTECOST. I am not familiar with that but that sounds typical of the kinds of licensing agreements we run into from overseas.

Senator ALLOTT. This goes back to what a great many have testified here today, that it is time we started looking after our own business. Thank you.

Senator MOSS. All right, the committee stands adjourned.

(Mr. Pentecost's prepared statement follows:)

STATEMENT OF DR. JOSEPH L. PENTECOST, TESTIFYING FOR THE NATIONAL INSTITUTE OF CERAMIC ENGINEERS, COLUMBUS, OHIO

I am testifying in behalf of the National Institute of Ceramic Engineers which represents about 1,700 active ceramic engineers in the United States. The National Institute of Ceramic Engineers is closely associated with the American Ceramic Society, our technical society, which currently has about 6,800 individual members (1). The National Institute of Ceramic Engineers is also an associate society in the Engineers Joint Council.

Our industry represents about \$10 to \$15 billion dollars in annual product value. This figure represents the value of the ceramic products alone, not the value of the entire automobile when we are considering only the spark plug insulators. Some of the major segments of this industry include:

	<i>Millions</i>
Abrasives.....	\$600
Plumbing fixtures.....	200
Dinnerware and pottery.....	200
Building products (portland cement, lime, gypsum, brick, drain tile, wall and floor tile).....	3, 000
Glass products (flat glass, containers, fiberglass).....	3, 500
Porcelain enamel and ceramic coating (appliance parts, signs, plumbing fixtures).....	300
Electronic and technical ceramics.....	700
Single crystals and optical materials.....	20
Carbon and graphite specialties.....	100
Refractories (furnace linings, temperature resistant materials).....	700

The ceramic industry is an important one, increasingly complex, and technology oriented. A brick may not appear to require engineering, but consider that clay is mined, beneficiated, formed to a precise shape, dried, fired to over 2000°F, and marketed profitably for less than 2¢ per pound. Gentlemen, that is a technological achievement in today's economy!

Today, I would refer you to a few statistics on technical manpower which supports this \$10-15 billion industry. First, please refer to the *Nonmetallic Materials* report prepared by the National Academy of Sciences in 1969 (2). This study is comprehensive and accurate in representing the manpower and research crisis which faces us in ceramic engineering.

According to this reference, since World War II, approximately 6,000 ceramic engineers and ceramic scientists have been graduated. This is an optimistic interpretation of Figure 10, page 34, which shows the number of BS, MS, and PhD's graduated. Obviously some PhD's also represent BS and MS degrees, so the effective total is probably about 4,500. A recent survey published in the *American Ceramic Society Bulletin* (3) shows approximately 5% of the total ceramic engineering graduates in military service and 15% in nonceramic related areas. This leaves approximately 3,600 of these ceramic engineering and ceramic science graduates in industry today, or roughly one technically trained ceramist per 140 employees in this segment of the industry.

A recent report for The National Institute of Ceramic Engineers prepared by William Brandt (4) as well as the National Academy of Sciences report points out that this ratio is not representative of the actual industry situation, but that physicists, chemists, metallurgists, and other engineers outnumber ceramists (over 5 to 1) in ten selected large ceramic industries with a total sales of \$1.5 billion.

One educator (5) considered the total number of companies recruiting on the campus and in ceramic publications and compared the total available graduates in 1969 and concludes that there were at least three companies seeking ceramists for each graduate. Even in the recent economic slow-down where segments of our technologically oriented economy have seen wide unemployment or under-employment, ceramic engineers have fared quite well. In the April 1971 issue of the *American Ceramic Society Bulletin* (6), there are two "positions wanted" ads and seven specific "positions available" type ads.

In a summary of a visit to Japan (7), Dr. Cyrus Klingsberg of the National Academy of Sciences points out Japan's emphasis in Ceramic Education.

"The three universities (in Japan) which offer ceramic engineering degrees graduate about 400 ceramic engineers a year * * *.

"For 1966 the number of Bachelor's degrees granted in ceramic engineering in the U.S.A. was 182, Master's 69, and PhD's 52. By contrast, for 1968 the annual rate in Japan was 420 for the Bachelor's, 100 for the Master's and 20 for the Doctorate. Taking into consideration the fact that the U.S.A. has a population twice that of Japan, then on a pro-rated basis, the Japanese are producing $4\frac{1}{2}$ times as many Bachelor's, 3 times as many Master's, slightly less than an equal number of PhD's in ceramic science and engineering."

As you know, segments of our industry have suffered from foreign import competition. Whiteware products (This is the term used to classify dinnerware, china, floor and wall tile, electrical porcelain, and similar products,) are among those under severe competitive pressure. In a report from a meeting of industry leaders held last month at Battelle to consider common problems in the \$800-million-per-year whitewares industry (8), it is stated:

"Concerted attention should be given to insuring that whitewares technology receives greater attention in ceramic technical education, * * *

An improved treatment of whitewares at the universities could stimulate progress in the industry."

The semiconductor industry is also plagued with ceramic problems. Ceramic packages for sophisticated semiconductor elements (the silicon chip for LSI) frequently cost several times as much as the processed silicon chip itself (9).

"One semiconductor maker puts it this way, perhaps stretching an analogy to make his point: 'How come we go through hundreds of operations to produce an integrated circuit and we can sell it for pennies, and it only takes a few steps to make a (ceramic) package and yet it costs ten times what the chip does?'"

I have only highlighted a few areas of concern to us. The National Institute of Ceramic Engineers is enthusiastically in support of S. 635 because we feel that this type of federal support of our industry is essential to continued healthy growth.

The need for additional federal research emphasis has been pointed out by the National Academy of Science in the report cited (10):

"The research funding picture reveals some startling facts. Thus, we find that to back up a \$200 million industrial research and development effort, there is only \$5 million of basic research at universities with less than one-half million coming from industry. The federal role in this area of technology has been relatively small so far. In two or three major areas progressive industrial managements have kept the nation's technology in the forefront. However, in others, because of the absence of novel forms of partnership between self-reliant traditional industries and the federal government, the latter has been excluded from playing any role in the development of the technology. The whiteware, enamels, and refractories industries fall in this category.

"Furthermore, in a negative sense, federal support of other areas, even of other branches of materials science, has drained off some students who might have entered the fields of interest to this Panel. The ratio of federally supported to industry supported research conducted is very low compared to other areas of technology, and this ratio in the preparation and characterization of nonmetallics is even lower than the equivalent figures for the other branches of materials science. We have attempted to summarize this picture of the source and location of research activity in Table 6."

Not only will this added research effort assist the industry technologically, but it can improve academic departments which are associated with institutes set up under this bill. N.I.C.E. believes that this will stimulate additional student interest, thereby increasing enrollment, as well as improve the quality of the academic program and hence the quality of the personnel graduated.

We see S. 635 as a direct benefit to many ceramic engineering departments currently located at land-grant universities and at other institutions as a part of Mineral Sciences or Materials Engineering Departments. We urge your early enactment of this legislation.

REFERENCES

- (1) *American Ceramic Society Bulletin* 49, 857 (1970).
- (2) *Nonmetallic Materials*, National Academy of Sciences, Washington, D.C., 1969.
- (3) *American Ceramic Society Bulletin* 50, 286 (1971).
- (4) William O. Brandt, "The Supply of Ceramic Engineering Personnel," September 25, 1969. (A report prepared from ACS-NICE Committee studies.)
- (5) Ralston, Russell, Jr., Department of Ceramic Engineering, Ohio State University.
- (6) *American Ceramic Society Bulletin* 50, No. 4, p. 22A (1971).
- (7) Cyrus Klingsberg, "Ceramic Research and Education in Japan," *American Ceramic Society Bulletin* 49, 322 (1970).
- (8) "Report of the Meeting on United Action in the American Whitewares Industry," Winston Duckworth, Chairman, Battelle Memorial Institute, March 9, 1971.
- (9) Stephen E. Scrupski, "Plastic-Ceramic Duel Stirs Up New Design Concepts for LSI Packages", *Electronics*, p. 79, April 12 (1971).
- (10) *Ibid*, Ref. 2, p. 46.

(Whereupon, at 4:55 p.m., the committee was adjourned.)

APPENDIX

(Under authority previously granted, the following statements and communications were ordered printed:)

STATEMENT OF HON. MIKE GRAVEL, A U.S. SENATOR FROM THE STATE OF ALASKA

I speak in full support of the pending bill, S. 635 to amend the Mining and Minerals Policy Act of 1970 in order to establish and fund a mining and minerals institute in each state.

What other witnesses have said in support of this much-needed legislation has impressed me a great deal. Several common themes have emerged both from academics and industry persons in the course of these statements, and I think they all have validity.

One recurring theme that I find persuasive is the enormous gap between how we treat the agricultural industry as a matter of public policy compared to how we treat the minerals industry (exclusive of oil). The result of this differing treatment can in part be seen by the standing of the two industries—both relative to each other and relative to the rest of the world. In the one case the U.S. is the undisputed leader in product, technology, and efficiency, and in the other we are just another member of the industry. And since the orderly growth of our economy still has something to do with commodity industries in the mineral field, I think it behooves us to make those public investments which promise such high yields.

A second theme is the unending problem of balance between investment in basic science and in applied engineering. The optimum use of our minerals resources requires that the mineral industry become a high-technology industry utilizing advanced techniques and methods not yet designed. Our sophistication in this field should not markedly lag that in the space program. It is important to have sufficient capability in engineering to make effective use of our scientific resources. The practical, pragmatic, operational aspects of the mineral and metallurgical sciences must be enhanced.

A third theme running through earlier testimony is the relationship of mineral and mining activities to current environmental considerations. The fact that the minerals industry—as with all other industries—does not have an unblemished past in terms of faultless environmental practices, should not blind us to the need for the continuance and further development of this basic industry with suitable environmental safeguards. We should be neither “gunshy” nor embarrassed about proposing the strengthening and expansion of our mineral sector, for it is a key element in any highly industrialized economy. The increased awareness of the need for environmental protection practices in the industry speaks for a greater investment in this field, not a lesser one.

I am in favor of institutional support for a minerals program in each state as envisioned by S. 635 and would only urge that a mechanism be included in the administration of the program so that duplication of effort and project activity and training state-to-state would be minimized. We don't need to rediscover everything fifty times over.

Having said this, the fact still remains that the physical mineralization of states does vary, as do the research and manpower needs. Some of the older states are well known geologically and practices suited to those situations are well developed. Others, like my state of Alaska, are at a very different stage and a program tailored to its peculiar needs would be called for. S. 635 allows this kind of flexibility.

You may have noticed that almost all articles about Alaska start with the statement “Alaska is a land of great mineral potential” or “Alaska is a storehouse of minerals”. These statements are probably true, but they contrast sharply with the present low level of mining activity in the state. Exclusive of oil and gas, the

minerals and mining sector in Alaska is at a low ebb by almost any measure—employment, income generation, value of product, tax contribution. For example, the total value of this mineral production in 1969 was only \$26 million, and within this figure sand and gravel made up \$15 million (a decrease from \$20 million the year before).

Still the potential is very real indeed. There is no reason to believe that Alaska is less well-mineralized than areas of Canada across the border where mining is flourishing. Other factors explain the differences. The high grade Kennicott Copper deposit north of the Arctic Circle is well known. Borite, coal and iron-bearing properties are being more fully explored along with off-shore gold-bearing placers. Much awaits investments in topographic and geologic information as well as investments in technology, transportation and other social overhead facilities.

Alaska presents a great opportunity for high paybacks to public investment in the minerals-field. Few other sectors (and perhaps few other states) offer so large a return for dollars expended. We have in existence in Alaska a quality university in the physical and applied sciences whose programs would be greatly enhanced by passage of S. 635. The need for training an adequate supply of scientists, engineers, mineral economists, and technicians is established; mineral resource research projects of high priority are plentiful in Alaska. In short, Alaska is a region where the purposes and provisions of S. 635 could be realized in exemplary fashion.

I urge Committee support of S. 635.

STATEMENT OF WILLIAM J. SMOTHERS, PH. D., P.E., PRESIDENT, THE AMERICAN CERAMIC SOCIETY

The following is an analysis of Senate Bill 635 to amend the Mining and Minerals Policy Act of 1970 based upon the experience and information available to The American Ceramic Society.

The American Ceramic Society has approximately 7,500 members, drawn from all areas of ceramic interest. It is the premiere publishing agency for scientific and esoteric ceramic-related data in the world. Through two monthly technical publications and several monographs published annually and some twelve national meetings each year the Society serves to record and disseminate the findings of the research and development of the members and contributors of its eleven Divisions, namely: Basic Science, Cement, Ceramic-Metal Systems, Design, Electronics, Glass, Materials and Equipment, Nuclear, Refractories, Structural Clay Products, and White Wares. Through two classes of membership the Society also makes use of some 1700 registered, professional ceramic engineers of the National Institute of Ceramic Engineers and the some 250 ceramic engineering and science educators through The Ceramic Educational Council.

The engineering and science community, to which the information disseminated by the Society is related, is engaged in the development and production of non-metallic minerals and subsequent processing into a variety of products with an annual value of some 15 billion dollars. There is no standard by which to judge the additional value of the contributions to society made by the educators, scientists, artisans, government employees and others whose participation in ceramic activity and development is not included in industrial production statistics.

The ceramic industry is a basic one in that its products are essential to all industries which employ high temperature processes, for example, the primary and secondary metals industries; electric power, both from fossil fuels and nuclear energy; petroleum and petrochemical; fine and heavy chemicals; and many others, including the ceramic industry itself.

The structural clay products, glass, and cement divisions of the industry produce a wide variety of products essential to the construction industry. The ceramic insulators, ferromagnetics, ferroelectrics, piezoelectrics, phosphors, and dielectrics of the electronic ceramic division of the industry are essential to this nation's electronics industry, including the computer industry. The glass division supplies the optical industry a wide variety of lenses, prisms, filters, and optical fibers. Ceramic materials serve unique roles in this nation's nuclear, space, and defense programs.

The prevailing deficiencies in this nation's ceramic research and development and training of ceramic engineers and scientists have been documented in the 1969 report of the National Academy of Sciences compiled by the Panel on Nonmetallic Minerals of the Committee of Mineral Science and Technology, a document with which the members of the Senate Interior and Insular Affairs

Committee is certainly knowledgeable. The American Ceramic Society is cognizant of the findings and recommendations of this most comprehensive study. Our national commitments of manpower, monies and materials over the past two decades to the nuclear, space, and numerous defense projects has served to deprive the ceramic industries and educational programs of the resources essential to sustaining this nation's past prominence in this basic technology. As a consequence the ceramic industry in this country cannot manufacture dinnerware, floor and wall tile, some electronic ceramics, optical glass, some specialized refractories and processing equipment in competition with products offered by foreign manufacturers. The plate and flat glass industry in this country has in the past five years acquired through license arrangements the complete technology for the float glass process, as developed by a British manufacturer, in an effort to provide a domestic supply of these glass products competitive in price and quality with that offered by foreign manufacturers.

There are other and increasing numbers of examples of declining ceramic technology which have an immediate and long term consequence upon our economy and security which should be of national concern. To reverse this trend there must be a significant increase in the education of ceramic engineers and scientists and funding for research and development. The data presented in Figure 10, page 34 of the National Academy of Science report *Nonmetallic Materials*, see attachment I, depicts the annual production of academic degree candidates in ceramics for the twenty-year period from 1947-1967, as developed from enrollment data compiled annually by the Statistics Committee of the Society's Ceramic Educational Council. In this twenty-year period the thirteen accredited ceramic engineering and eleven ceramic science departments in the country awarded some 6,000 degrees. However, inasmuch as those earning graduate degrees were recipients of two or three of the degrees awarded, the number of individuals educated during this period was only some 4,500. In the five-year period subsequent to the last year included in attachment I, the annual reports of the Ceramic Educational Council indicate that some 800 additional individuals have earned one or more degrees in the field, thus, bringing the total since 1947 to some 5,300.

ATTACHMENT I

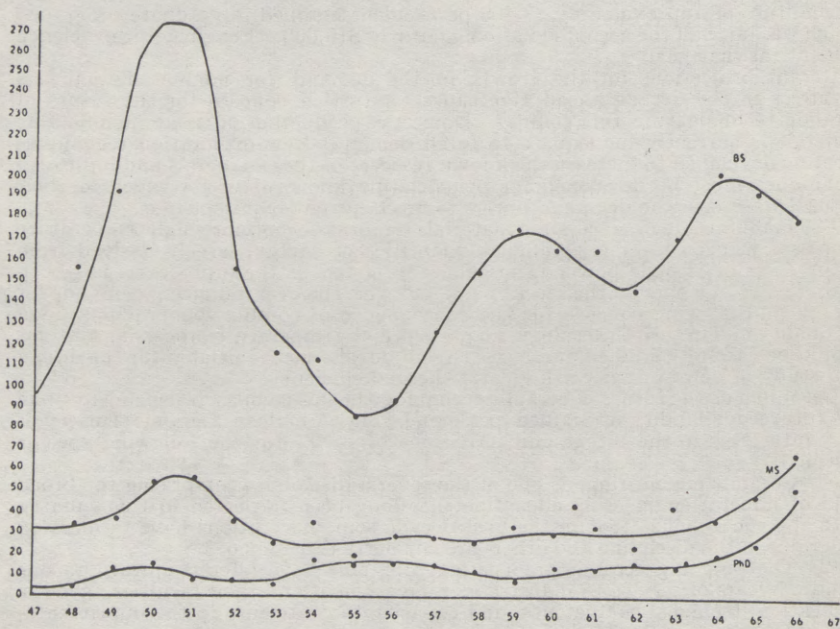


FIGURE 10 Degrees granted in ceramics.

A survey published in the March issue of the *Bulletin* of the Society indicates that approximately 5% of the total graduates are in the armed forces and some 16% are engaged in activities unrelated to the field, such that of the 5,300 awarded degrees in the past quarter century only some 4,200 remain associated with the field through employment in industry, government, or education. This number indicates that there is only one technically-trained ceramist per 140 employees in the ceramic industry, which number is well below the average in other basic industries. The survey cited above also indicates that only 18% of the 4,200 graduates active at this time, or some 750 individuals, are engaged in research and development. Of these, some 300 are employed in government and education such that on the average there is no more than one trained ceramist engaged in research and development per eight industrial organizations processing ceramic materials.

These data should evidence adequately the reason for our lag in ceramic technology; however, the annual national expenditure for nonmetallic mineral research and development is another obvious contributor. The previously cited National Academy of Sciences report provides a survey of such expenditures in 1966 by industry, government, and educational institutions, which was little more than 1% of the total value of ceramic products manufactured in that year. By any criteria, this annual rate of expenditure is grossly inadequate to sustain the technological progress of any basic industry. The excellent analysis of the contributions to the open technical literature in the field, as summarized in Table 9, page 37, of the National Academy of Sciences report, clearly evidences the consequences of this limited R&D investment in that U.S. contributions to the technical literature declined from 32.2% of the total in 1951 to 21.1% in 1963, while those of the USSR increased from 12.5% to 41.8% over this twelve-year period. Unfortunately, the quality or significance of the findings reported in the literature cannot be assessed from such an analysis, but there is a clear consensus within our engineering and scientific community that this aspect of our research and development activity is of equal or possibly greater concern.

There is, of course, a direct relationship between the number of students educated in the field and that portion of the annual R&D expenditure available to the universities. The National Academy of Sciences' Panel on Nonmetallic Materials estimated this expenditure in 1966 at \$5 million, of which \$2.7 million was administered by 24 institutions participating in the Society's enrollment survey. For these latter institutions this level of funding provided an average annual expenditure of approximately \$7,400 per student enrolled in graduate programs, which was but half the accepted national norm of \$15,000 per engineering or science student for that year.

Recent projections for the growth in the demand for nonmetallic mineral resources in the decade ahead give cause for further concern for the future of ceramic technology in this country. Domestic production of some nonmetallic minerals is currently inadequate to fulfill demand. New exploration techniques must be developed to increase the known reserves of these minerals and improved techniques must be developed for beneficiating known deposits which in their natural state lack the degree of purity to meet current requirements.

The manufacture of all ceramic materials requires one or more high temperature processes which consume significant quantities of energy, largely derived from natural gas or electric power. The efficiency of few of these processes has been examined at any time in the recent past, and with the ever mounting demands for energy and growing concern for the consequence of combustion products upon air quality and in turn the ecology, all present high temperature processing systems should be carefully studied and research and development initiated for the design and study of new systems with greater thermal efficiency.

Inasmuch as the future of ceramic technology in this country is dependent upon the future availability of trained personnel, The American Ceramic Society is very interested in the intent and provisions of S. 635 for the following specific reasons:

- (1) Ceramic engineering, as one of the several disciplines comprising the broad field of mineral engineering education, has long been neglected in this country with the consequence that in the past decade some institutions have terminated programs in the discipline and others are currently threatened.

- (2) The on-going ceramic engineering programs have offered upward to one hundred years of service to industry and government and their faculties have the dedication, technical competence, and capacity to contribute to the implementation of the intent of S. 635.

- (3) This legislation could serve to evidence to the general public a national concern for the many problems confronting the country in the management of its

natural resources, particularly to the young people of this country who must be encouraged to consider career opportunities in one of the mineral engineering fields, if this country is to regain its former technological pre-eminence in this field.

(4) The revitalization of academic research and development, as intended by the institutes to be established through the provisions of this legislation, would serve to strengthen the total academic programs in all mineral engineering disciplines, and an important secondary benefit of the research and development activities of the institutes would be the increase in trained manpower to fill the needs of industry, government and education.

STATEMENT OF W. A. BOYLE, PRESIDENT, UNITED MINE WORKERS OF AMERICA

Mr. Chairman and members of the committee, on behalf of the United Mine Workers of America we appreciate the opportunity to submit testimony on S. 635.

The United Mine Workers of America supports the provisions of S. 635 and urges the Subcommittee on Minerals, Materials and Fuels to expedite its early enactment by the Congress of the United States. Our support for S. 635 is based upon two basic premises.

First, it is obvious that the United States depends, to an increasing degree, upon the production, distribution and consumption of energy. Energy, the keystone of our industrial economy, is the basis for our advanced civilization and will remain so for the foreseeable future.

If the United States is to continue to be an energy intensive society and if it is to meet the challenges inherent in the demands of our citizens for a better life both quantitatively and qualitatively we, as a nation, will have to reorder our research priorities, especially as they relate to energy.

Fortunately, America has been blessed with abundant energy resources. Of these resources, coal is by far the largest, representing approximately 80% of the total fossil fuel reserves of the United States.

Furthermore, it is possible to use coal not only in its original form, but also to convert it to liquid and gaseous fuels, fuels which now constitute the major source of energy for our industrial and residential consumption.

All of the predictions for the future indicate that Americans will continue to use energy in ever increasing amounts. Indeed, since the mid-60's there has been a sharp upsurge in the rate of growth of energy consumption. This upsurge has forced a reevaluation by economists and others concerned with energy of their predictions of the future and has brought about, in part, the energy crisis now confronting many parts of this nation.

If we are to continue to use energy in massive amounts we must develop technology to improve its production, distribution and utilization. The need to develop technology is the second basic premise which leads us to support the principles embodied in S. 365.

For many years the American people were able to use energy with little regard for the technology surrounding its production, distribution and use. America has wasted its energy resources and has permitted this development without consideration for environmental, economic or sociological factors. Unfortunately, the result of this past neglect has been both an economic and ecological disaster. Large parts of our country have been destroyed by strip mining, oil spills and other direct abuses. Thousands of coal miners and other energy workers have been killed or permanently injured by a failure on the part of both industry and government to recognize the basic challenges inherent in the development of a safe industry. Furthermore, damage to the environment of our major metropolitan areas has been great because America has not devoted the necessary resources to develop a clean technology.

The coming of the atom has not helped. To the contrary, the atom poses the threat of ecological disaster of unparalleled magnitude. This threat must give pause to those who promote the atom as well as to government officials who are concerned not only with the well-being of the present generation but with untold generations in the future.

The time is long overdue for America to reconsider the technological basis upon which our industry is built. It is time that America devote resources to updating that technological base and providing a mechanism whereby increasing numbers of talented young scientists and engineers can devote their efforts to the improvement of the technology surrounding the extraction and utilization of energy and mineral resources.

In our opinion, S. 635 is one such mechanism. It would provide part of the financial resources which are essential to the attraction and retention of young

engineers and scientists. It would make possible the money which could be used by these young men to pursue projects of interest to them and to the nation as a whole.

It would also make possible the creation, within each appropriate state, of a center of excellence for both the training of engineers and scientists and for the pursuit of proper research and development projects dealing with the energy and mineral industries. Such centers of excellence would act as magnets to attract top scientific talent to the mineral industry. It would, in effect, be a repetition of the process which was used so efficiently in the development of our space industry. With the attraction of such talent to the problems of energy and minerals would come solutions to the technological problems confronting these industries. Such talent would be used to develop methods of reducing pollution, of improving health and safety, of upgrading the efficiency of power generation and for other appropriate problems.

In essence, the passage of S. 635 would provide the financial resources, but more important, would lend congressional credence to the principle that energy must both now, and for the foreseeable future, be the cornerstone of American industrial and human progress.

The committee has heard from many representatives of the coal and mineral industries on this question. It has also heard from many of the leading academicians and other interested professionals on this subject. We do not intend to restate what has already been said. However, it is obvious that unless we order our priorities and allocate sufficient resources of men and money to the question of energy and to the problems which the growth of energy poses, America is indeed faced with a grave economic and political crisis.

Therefore, Mr. Chairman, we support the passage of S. 635 and we urge its early enactment by the Congress. Thank you.

MACKAY SCHOOL OF MINES,
UNIVERSITY OF NEVADA,
Reno, Nev., April 23, 1971.

HON. GORDON L. ALLOTT,
Member, Senate Subcommittee on Minerals, Materials, and Fuels, Senate Office Building, Washington, D.C.

DEAR SENATOR ALLOTT: A moments reflection is sufficient to convince a person that there are but two basic and fundamental industries and that all other human economic activity depends upon the satisfactory operation of: (1) the industry involved with living resources; that is agriculture (including forestry, fishing, etc.) and (2) the industry involved with non-living resources; that is the mineral industry. Without either of these industries; which compose the first level of human economic activity; the world, as we know it, ceases to exist and man becomes a wandering animal. Thus it is folly to debate which is more important: agriculture or mineral industry. Other levels of human economic activity are important to the life of our nation but they cannot exist without the first level!

Some hundred years ago Congress recognized that a healthy agricultural industry was necessary to our nation's well-being and by means of the Morrill and other Acts created agricultural research and training institutes throughout America. The results are world famous. Regretably, research and training institutes for the non-living (earth and mineral) resources were not established at that time. Thus, America, although well-supplied by nature with mineral materials, has paid a heavy price through lack of research and training. The nation that does not consider the economic condition of each of its two basic industries may soon lose its right of free choice in guiding its own future in the world!

The time has come for America to think about its earth and mineral (non-living) resources. The education and research necessary for these resources to be properly extracted and used must be supported and encouraged. Then, and only then, will America know that both of its basic and fundamental industries will be healthy and will contribute to our Nation's safety and well-being.

As Dean of one of America's few remaining mineral industry colleges and as Director of one of our most active state bureau's of mines, I sincerely urge you to support the passage of S. 635; which calls for the establishment of mineral resources research and training institutes throughout America.

Most respectfully yours,

VERNON E. SCHEID,
Dean and Director.

UNIVERSITY OF KENTUCKY,
Lexington, Ky., May 6, 1971.

HON. GORDON ALLOTT,
U.S. Senator, New Senate Office Building,
Washington, D.C.

DEAR SENATOR ALLOTT: This letter constitutes a brief statement in support of S. 635 the hearing for which was held on April 28 of this year.

Many statements were entered into the record covering all aspects of the desirability of this Bill and I will not repeat them to any extent.

The Bill is written to include benefits to all states, regions and areas to which the minerals industries and its related activities are of value.

There are two possible inclusions which I will suggest for S. 635.

1. Change Line 6 on Page 6 to read—"shall designate an officer from its Mineral Engineering Faculty appointed by its governing authority"—.

This change would be intended to insure that the administration of the usage of these monies would be in the hands of people acquainted with the minerals industry and would be less likely to allow usage of the money in fields foreign to the minerals industry and those who use the products of the minerals industry.

2. Include a specific statement allowing support of undergraduate scholarships.

This Bill can be the means of assuring an adequate supply of technically trained men for the minerals industry and it has my strong support.

Yours very truly,

TED D. HALEY,
Director of the Mining Option of Civil Engineering.

UNIVERSITY OF NORTH DAKOTA,
Grand Forks, April 8, 1971.

HON. QUENTIN BURDICK,
U.S. Senate,
Washington, D.C.

DEAR SENATOR BURDICK: I wish to bring to your attention and solicit your support for a new bill, S. 635, amending the Mining and Minerals Policy Act of 1970 (PL 91-631) which has been referred to the Committee on Interior and Insular Affairs and is, I understand, to be discussed in hearings approximately the 28th of April.

This bill is of considerable interest to those of us at the University of North Dakota who are interested in and involved in research for the welfare of the state. Specifically, this bill would permit the creation of a statewide research institute at the college or university in the state having a school of mines (i.e., UND). The purpose of the institute would be to conduct research into and stimulate mining, land reclamation, underground reservoir utilization, mineral economics, and related environmental research.

It is my impression that an institute similar to the Water Resources Research Institute would be permitted and encouraged by this law. The University of North Dakota, being the institution having the School of Mines for the state, presumably would be in a position to undertake the creation and administration of such an institute. The University would be in a unique position to carry out a significant component of the research in the general area of mining because of our past activity in lignite research, the location on the UND Campus of the U.S. Bureau of Mines Lignite Research Laboratory, and the extensive research carried out by the Department of Chemical Engineering on lignite gasification and liquefaction, all of which now are being brought to bear on the possible acquisition of the process development unit from the U.S. Office of Coal Research through the P & M Mining Company.

My point is that the University of North Dakota has demonstrated the competence to carry out research in accord with the proposed S. 635, and the University of North Dakota is in a position to significantly assist in research toward the development of mineral industries in the State of North Dakota. I believe this bill would benefit the whole State of North Dakota. I would appreciate very much your support of this legislation.

Sincerely yours,

A. WILLIAM JOHNSON,
Dean, Graduate School.

A PROPOSED POLICY FOR
MINERAL RESOURCE DEVELOPMENT
IN ENGINEERING SCHOOLS
for
THE DEPARTMENT OF THE INTERIOR

The report of a panel on Mineral Resource Development

convened by

The Commission on Education

of

The National Academy of Engineering

March 25-26, 1971

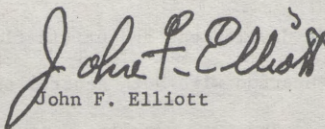
May 4, 1971

FOREWORD

Early in 1971, it became clear that there was a need to review and reformulate the policy to guide the Department of the Interior and the Bureau of Mines in current programs and possible future programs being supported by the Department relative to mineral resource development in the engineering schools in the United States. To assist in the development of that policy, a panel of educators was convened that was broadly representative of institutions in the United States which are concerned with the education and training of engineers in the areas pertinent to mineral resource development.

The Panel met in the Department of the Interior in Washington, D. C. on March 24-25, 1971. This report summarizes the deliberations of the Panel.

For the Panel



John F. Elliott

Cambridge, Mass.
May 4, 1971

Report on
A POLICY FOR
MINERAL RESOURCE DEVELOPMENT IN
ENGINEERING SCHOOLS

SUMMARY STATEMENT

The Panel to promulgate a policy for mineral resource development met on March 25-26, 1971 under the auspices of the Commission on Education of the National Academy of Engineering. Members of the Panel were drawn from academic organizations in the United States concerned with mineral resource development. The Panel was convened to assist the Department of the Interior and the Bureau of Mines in the formulation of a policy for a program of mineral resource development for engineering education in the United States. The program would be directed to the establishment and maintenance of a strong technological base for the development and utilization of our mineral resources and would be concerned with both general and specific problems relative to raw materials and fuel supplies, industrial working conditions, impact of minerals extraction methods and fuels utilization on the environment, and development of competent and qualified engineering graduates for the field.

The Panel recommends for the program of support of mineral resource development in engineering schools that:

1) There be flexible continuing support for programs of research and engineering projects and for development of able, qualified graduates, faculty, and practicing engineers for the field. Specific research and

engineering development programs in the form of projects would be funded by "Minerals Project Grants." Support for institutions for the development of a sound base for engineering education in the field would be in the form of "Minerals Technology Awards" and support of programs of development or improvement of an individual's technical competence would be made in the form of "Minerals Technology Fellowships."

II) Proposals for all types of grants would be evaluated on the basis of merit, and the potential for long term enhancement of the capability of mineral resource development in the United States. The evaluation of proposals and the decisions on awards of support should be based on the established mission of the Bureau of Mines, but should be independent of existing research programs and funding within the Bureau.

III) An Advisory Committee (or Commission) on Policy for Education in Mineral Science and Technology should be established. This Committee would assist the Department of the Interior and the Director of the Bureau of Mines in the formulation of policy and would advise the Office of University Relations of the Bureau on policies relating to the appraisal of proposals and evaluation of the performance of programs supported by grants and awards.

IV) Interdisciplinary activities on projects and programs should be encouraged, where appropriate, between the engineering departments concerned directly with mineral resource development and other departments in the educational institution. Where possible, joint programs between institutions should also be encouraged.

May 4, 1971

For the Panel by its
Report Committee

Thomas V. Falkie
George R. Hill
James H. Kent
John F. Elliott, Chairman

A POLICY FOR
MINERAL RESOURCE DEVELOPMENT IN
ENGINEERING SCHOOLS

INTRODUCTION

It is in the public interest for the United States to establish and maintain a strong and viable technological base for the development and utilization of our mineral resources. That technological base is essential to obtaining the necessary supplies of fuels, metals and non-metallic materials of adequate quantity and quality and of reasonable cost, to protect the health and safety of the work force in the minerals and metals extraction industries and of the general public, and to avoid contamination and pollution of the air, water and land in the process of obtaining these supplies.

Early in the Twentieth Century, the U.S. played a leading role in advancing the technology by which minerals are extracted from the earth and processed. That position has been weakened seriously in recent decades, in spite of the strong emphasis on science in the U.S. in the post-sputnik era. The major cause of the erosion of the technological base for the utilization of mineral resources has been that the level of effort for what might generally be called mineral resource development has been woefully inadequate because of insufficient financial support of technological development programs, particularly in the engineering schools. This has resulted in a serious decline in the output of able, qualified engineering graduates for the field.

The staff of the U.S. Bureau of Mines and the Commission on Education of the National Academy of Engineering have been working closely to initiate effective programs for minerals resource development in the research and educational efforts of engineering schools in the United States. The primary goals are to strengthen the technological base for minerals extraction and utilization and to increase the number of ably trained engineers in the field. Immediate goals are the improvement of mine health and safety, and an increase in the number of qualified graduates with backgrounds in mining, mineral engineering, fuels technology, process metallurgy, ceramics and related fields.

To assist in establishing a policy for mineral resource development in engineering schools, a two-day meeting on the subject was held under the auspices of the Commission on Education of the National Academy of Engineering at the Department of the Interior, Washington, D.C. on March 25-26, 1971. The agenda and the list of panel members and other participants in the meeting are Appendices I and II. The discussion at the meeting covered a wide range of topics of importance to the fields of minerals and fuels extraction, processing and utilization. The attention of members of the group was drawn to several bills that are now being considered by Congress; the Green Bill (HR 3492), the Saylor Bill (HR 6788) and The Allott Bill (S. 635). The nature of several other government programs for supporting problem-focused and project-oriented research, such as the program of Research Applied to National Needs (RANN) of the National Science Foundation, were discussed. The mission of the Department of the Interior in the areas of mineral resources management and development, and the role of the Bureau of Mines

was considered at some length. The important aspects of the discussion and the resulting recommendations with regard to the Policy for Mineral Resource Development in Engineering Schools are reported here.

THE CHALLENGES

Some of the most urgent challenges facing the field of minerals extraction and the university community that serves it were presented by the Secretary of the Interior, Mr. Rogers C. B. Morton, the Assistant Secretary of the Interior, Mr. Hollis M. Dole and the Director of the Bureau of Mines, Dr. E. F. Osborn. These and other challenges were discussed by the group in relation to the needs of the country and the present and possible future responsibilities of the Department of the Interior and the Bureau of Mines.

It is imperative that the working conditions in the minerals extraction industries be improved. Immediate action for the improvement in the health and safety of miners is being taken by the Bureau of Mines as empowered by Congress in the Coal Mine Act of 1969 and the Metal and Non-metal Health and Safety Act. In the longer term, new mining and processing methods must be developed which will eliminate hazardous and unhealthful working conditions, improve the working environment, and preserve the general environment. The educational community has several responsibilities in this area. First, more trained manpower is needed immediately for the mine inspection force. Second, a greater exchange of ideas and information on health and safety in the mines is needed between industry, government, the miners, and the educational community. Also, there should be greater emphasis on health and safety in the education of mining engineers. Third, new mining and minerals processing

methods must be developed. Suitable alteration of the technology by which minerals are extracted and processed to eliminate hazardous and unhealthful working conditions should also result in an improvement in general working conditions and thereby make it easier to attract an adequate supply of both trained and untrained personnel for the field.

The engineering schools are expected to develop an adequate supply of able, technically qualified people necessary to the production and processing of our mineral resources. In the past, the research and educational commitments to the field have been at much too low a level; in general there has been very little financial support for programs, and students in our engineering schools have had very little interest in the field. An important part of the problem in the post-sputnik era has been that the major thrust in our engineering schools has been to enhance the capability in applied sciences as needed in the space program, the development of computers, the electronic industry, materials development, applied mathematics, etc. The very large flow of funds in these areas has directed the attention of the faculty, administration, graduate students, and undergraduate students towards the sciences and away from the more technologically oriented fields, many of which involve the socially oriented demands for concern for health, safety, and care for the environment. The result has been that the areas of importance to mineral resource engineering are in a seriously weakened state at a time when the public interest could and should be served by able technical leadership and an adequate number of qualified graduates. Currently, there are very few people in the related undergraduate and graduate programs in the colleges and universities.

Not only must the educational community be stimulated into vigorous activity, but it must meet the challenge of incorporating a stronger technological focus into the educational experience at the undergraduate and graduate levels and into the research and development efforts of the faculty in programs of mineral resource engineering. Although the problems to be treated fall for the most part in the general purview of departments traditionally responsible for mineral resource engineering, many are interdisciplinary in character. Thus there is the additional challenge to the engineering schools to find ways of involving people from diverse areas in the search for solutions to these problems.

A further challenge to the university is to find ways to involve graduate research and study with project-type programs in which a range of issues interact. These are typically engineering projects that might, for example, incorporate problems of design, materials behavior, economics, the environment, etc. A project which relates to a broad range of real issues must involve, where appropriate, other disciplines. To meet this challenge, methods must be developed for defining the scope and scale of projects so that they are compatible with the academic purpose, for funding the work and of monitoring its development and its progress, and for coordinating effectively the work with related government programs, industrial efforts, and projects in other academic institutions.

There is also the need for revitalization of present academic programs in the area of mineral resource engineering. The most important requirement for meeting the long term need for technological advances is to develop an innovative faculty that has flexibility and perspective with regard to the important issues, and a good analytical base by which

the quantitative and qualitative factors of a project can be inter-related. The general emphasis should be for the students and staff to acquire the competence to tackle substantial and relevant problems in the field of mineral resource development, and to obtain the participation of people from other fields as needed.

SOME POLICY GUIDELINES

The membership of the panel agreed that a vigorous program of support of mineral resource development in the engineering schools by the Department of the Interior could lead to advances in the technological base of the minerals extraction industries and would result in an increased supply of able engineering graduates.

Development Projects - Mission-oriented, project-type research and development programs are considered to be the best means for advancing the technology and grappling with socially related problems. Such projects can involve faculty and graduate students in an engineering experience, consequently, they offer an excellent means for developing a competent faculty and able qualified engineering graduates.

It was stressed that an effective technical project usually has many facets, thus it requires interdisciplinary effort. This in turn enhances the educational experience of the participating students and faculty because of the range of options to be considered and the judgments to be made involving diverse values. It is anticipated that many of the projects relating to mineral resource development would naturally find a home in the areas of mining engineering, mineral engineering, process metallurgy, fuels technology, ceramics engineering, etc. Including people from other disciplines in a program as appropriate will

help to ensure viable technical and educational activities. Interaction with personnel from government agencies, industry, and other academic institutions should also be encouraged.

A proposal for a project would be submitted by an educational institution in response to a general public statement by the Bureau of Mines that it would support research and development related to certain of its missions. A proposal would be judged on its merits, its relationship to the mission, the competence of the people and organization submitting it, and the potential of the project for enhancing the capability of the staff of the institution for meeting the longer term goals of mineral resource development. It is suggested that the support be in the form of a "Minerals Project Grant" for a time ranging from 2 to 5 years, as may be appropriate.

Personnel Development - The potential of an organization for developing able, technologically trained graduates and faculty should be stimulated by block funding, where applicable. For example, to provide undergraduate students with direct experience with engineering work, an organization might seek special support to permit students to participate in the work on a project. Support of this kind would be desirable where in ordinary circumstances the nature of a project might preclude having an inexperienced person as a regular participant in the project. Another example of the use of this type of funding would be the support of a new curriculum or course in a technological area pertinent to minerals resources development. Funding of this type might be by "Minerals Technology Awards."

It was considered important that funds be made available to people seeking to improve their own technical competence in areas of importance to mineral resource development. Examples of activities where support would be important are found in the sabbatical type of programs for faculty and practicing engineers in industry and government who desire to spend an extended period in study for personal development or who would like to participate in a development program at another organization. Grants to cover unusual expenses (like Guggenheim Fellowships) of moving, travel, etc. would make it easier for engineers to expand their horizons, and would be particularly valuable to younger faculty. Support of this type of activity might be in the form of "Minerals Technology Fellowships." An important use of the fellowship would be to attract able young people from other areas into the field by providing them with support for a year of graduate study in some aspect of the development of minerals science and technology.

Proposals for Minerals Technology Awards and Fellowships would be submitted by an institution or individual in the same manner as those for Minerals Project Grants. A proposal would be judged on its merits, which would include the competence and potential for growth of the institution and the prospects for the development of technical competence for work in the field by the people involved.

A Policy Committee - It was recognized that the policy by which the Department of the Interior administers its programs with the engineering schools should be kept flexible and responsive to changing needs and purposes. The Panel urges that an Advisory Committee (or Commission) on Policy for Education in Mineral Science and Technology be established. This Committee would have the responsibility of assisting the Director

of the Bureau of Mines in formulating the policies relative to mineral resource development and the pertinent programs in the engineering schools. The Committee members should be technically able and progressive and that all selected have an appreciation of the need to improve the technological base for minerals resource development in the United States. Not all of the members need have backgrounds in the minerals area. Candidates for membership on the Committee should be sought from all areas of government, industry, and the universities. To obtain the services of able people for this Committee, it is proposed that it be organized through the National Academies of Sciences and Engineering with the advice and counsel of the Secretary of the Interior and Director of the Bureau of Mines.

It is considered mandatory that impartial procedures be established to evaluate proposals for support of the various types of programs in the manner outlined earlier. Such procedures should protect the in-house research programs of the Bureau of Mines and preserve the integrity of the project reviews. No attempt was made to spell out the details for a procedure, but the methods used by the National Science Foundation and the Army Research Office of Durham were cited as being satisfactory. It was emphasized that the individuals making the evaluation should have an understanding and appreciation of the character and importance of the technological aspects of the program. This constitutes a special challenge that is not fully understood by some funding officers and engineers now active in other areas of government. The Office of University Relations of the Bureau of Mines would be guided by the results of the evaluation of proposals in making grants, but it would have the primary responsibility in deciding the value of a given proposal relative to the missions of the Bureau. The complete separation of funding in the Bureau

of Mines of in-house programs and programs external to the Bureau is considered essential to the success of the efforts in the engineering schools.

The Office of University Relations of the Bureau of Mines should also establish procedures for evaluating the performance of individuals and institutions who have received grants. While the results of an evaluation may be considered to be confidential, the standards applied and the method of evaluation should be made known generally.

The Advisory Committee on Policy should figure prominently in formulating the policies and methods for the evaluation of proposals and in the appraisal of results. The Panel did not consider the details of whether these matters should be handled by a sub-group of the Committee or by a separate committee organized specifically for the purpose.

Technology and Academia - Recent trends in the development of relatively open engineering curricula in many institutions may make it difficult to provide an educational experience for the undergraduate that has a strong technological focus within a 4 year program for the baccalaureate degree. This problem may be alleviated by technologically oriented course work in graduate programs that can be used as electives by undergraduates in the senior year. Another approach to the problem is the development of a program of internship of 12 to 24 months in technologically oriented study and work on a minerals development project, which would lead to a master's degree in some area of minerals resource engineering. The use of technologically oriented research activities as a base for doctoral work constitutes a challenge to the traditional concepts of the type of research

suitable for doctoral theses. General recognition of the challenges inherent in engineering work of high quality and the maintenance of high standards of performance by engineering faculty have resolved this problem in several institutions. It is clear that recognition is needed that the educational policies in graduate schools which lead to inwardly directed scholarship should be modified¹ to include outwardly directed professional training. However, there remains the issue that work on certain types of project-oriented efforts do not naturally fit into doctoral programs. Perhaps "Doctor of Engineering" programs, designed and administered by faculties of professional schools, could provide a more rational approach to the problem of educating and training technologically focused engineering practitioners at the advanced level. Also, the graduate engineers degree used by some institutions could be fitting recognition of academic achievement at the post-baccalaureate level.

The promotion of competent faculty members who participate heavily in a field away from their area of specialization has always been a source of difficulty in academic organizations. This matter is primarily the responsibility of an individual's own institution, but it does relate directly to the challenge for the development of competent, active faculty having a technological focus. Programs which encourage joint appointments between departments within an institution, and the use of Minerals Technology Fellowships to encourage able young people to accept the challenge of moving into the field of mineral resource development are two possible ways of handling this question.

The program of accreditation of engineering curricula by the Engineer's Council for Professional Development can be used advantageously in changing, broadening, and modernizing the undergraduate curricula in the areas pertinent to mineral resource development. It was felt that dedicated work on the ECPD program by leaders in the field through the professional societies such as the American Institute of Mining, Metallurgical and Petroleum Engineers will assure continued development of progressive policies with regard to curricula accreditation.

APPENDIX I

MINERAL SCIENCE AND TECHNOLOGY EDUCATIONAL POLICY

SPONSORED BY:

Commission on Education and Bureau of Mines
National Academy of Engineering Department of the Interior

CHAIRMAN: Dr. Guy T. McBride, Jr.
 President
 Colorado School of Mines

Secretary's Conference Room (#5160)*
Department of the Interior Building

18th and C Streets, N.W.
Washington, D.C. 20240
MARCH 25 - 26, 1971

THURSDAY - MARCH 25, 1971

MORNING SESSION: 9:00am - Noon

GREETINGS: Secretary of the Interior
 The Honorable Rogers C. B. Morton

INTRODUCTORY REMARKS: Assistant Secretary--Mineral Resources
 The Honorable Hollis M. Dole

INTRODUCTIONS: U.S. Bureau of Mines Staff
 Dr. E. F. Osborn -- Director

 Commission on Education Staff
 Dr. Newman A. Hall -- Executive Director

PURPOSE OF MEETING/REVIEW:

- I. Commission on Education--National Academy of Engineering
 - a) Philosophy
 - 1) Function
 - 2) Objectives
- II. U.S. Bureau of Mines--Department of the Interior
 - a) History/Function
 - b) Current Activities
 - c) Office of University Relations
- III. Mineral Science and Technology

Relationship with National Academy of Engineering--
Commission on Education and the U.S. Bureau of Mines

. . . LUNCH BREAK . . .

MINERAL SCIENCE AND TECHNOLOGY EDUCATIONAL POLICY

THURSDAY - MARCH 25, 1971AFTERNOON SESSION: 1:30pm - 4:15pmIV. University's Role in Mineral Science and Technology
(as related to Research and Education)

V. New Opportunities for Universities

- 1) RANN
- 2) Relevance
- 3) Interdisciplinary Concept
- 4) Environment
- 5) New Concepts (i.e., Multi-University Projects;
Multi-Department Federal and University Programs)

CLOSING REMARKS/INSTRUCTIONS: Dr. McBride

DINNER: Cameron and Tayloe Room (1st floor) 6:00pm
 COSMOS CLUB
 2121 Massachusetts Avenue, N.W.
 Washington, D.C.

FRIDAY: - MARCH 26, 1971MORNING SESSION: 9:00am - NoonVI. Interaction between Universities and Government --
Problems Needing Solutions

- a) Structure and Staffing
 - 1) Universities
 - 2) Government
- b) Financial
 - 1) Universities
 - 2) Government
- c) Legislation
 - 1) Federal
 - 2) State

VII. Immediate Problem Areas

- a) Relationship of Research to Education
- b) Coordination of Research
 - 1) University and Government
 - 2) In-House vs. Out-House

CLOSING REMARKS

FINIS

APPENDIX II

MINERAL SCIENCE AND TECHNOLOGY EDUCATIONAL POLICY
Meeting, March 25-26, 1971Panel Members:

W. Edward Lear
Dean, School of Engineering
University of Alabama

Earl H. Beistline
Provost
University of Alaska

Willard C. Lacy, Executive Head
Dept. of Mining and Geological Engineering
University of Arizona

Douglas Fuerstenau
Professor of Metallurgy and Chairman,
Dept. of Materials Science and Engineering
University of California at Berkeley

Menelous D. Hassialis
Chairman, Division of Ocean Engineering
Columbia University

Guy T. McBride
President
Colorado School of Mines

Rolland R. Reid
Dean, College of Mines
University of Idaho

Ted D. Haley
Associate Professor of Mining Engineering
Department of Civil Engineering
University of Kentucky

John F. Elliott
Professor, Department of Metallurgy and Materials Science
Massachusetts Institute of Technology

James A. Kent
Dean, College of Engineering
Michigan Technological University

Theodore J. Planje
Dean, School of Mines and Metallurgy
University of Missouri at Rolla

Panel Members: (cont'd)

Stirling A. Colgate
 President
 New Mexico Institute of Mining and Technology

Thomas V. Falkie
 Head, Department of Mineral Industries
 Pennsylvania State University

Earl Cook, Associate Dean of Geosciences
 College of Geosciences
 Texas A & M University

George R. Hill
 Dean, College of Mines and Mineral Industries
 University of Utah

J. Richard Lucas
 College of Mining Engineering
 Virginia Polytechnic Institute

Jay Hilary Kelley
 Dean, School of Mines
 West Virginia University

Bezalel Haimson
 Department of Metallurgical and Mining Engineering
 University of Wisconsin

Robert W. Heins
 Dept. of Metallurgical and Mining Engineering
 University of Wisconsin

Department of the Interior:

Secretary of the Interior Rogers C. B. Morton (Greetings)

Assistant Secretary Hollis M. Dole (Introductory Remarks)

Bureau of Mines Personnel:

Elburt F. Osborn
 Director

Alvin Van Valkenburg
 Chief, Office of University Relations

John P. Cannon
 Special Assistant to the Director, Office of University Relations

