Testimony

Oversight Hearing on the Aging of the Energy and Minerals Workforce;

***A Crisis in the Making*?**

SUBCOMMITEE ON ENERGY AND MINERAL RESOURCESS
COMMITTEE ON ENERGY AND COMMERCE
UNITED STATES HOUSE OF REPRESENTATIVES
WASHINGTON, DC

July 8, 2004

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My name is Mary Poulton and I am head of the Department of Mining and Geological Engineering and a Professor at the University of Arizona. I want to thank Chairwoman Cubin and the entire Subcommittee on Energy and Mineral Resources for holding this hearing on the Aging of the Energy and Minerals Workforce. We are faced with a situation where the engineering workforce in the minerals and petroleum sectors are aging and we are losing our capability to educate the next generation of engineers because of the frail state of mining engineering and petroleum engineering departments at US universities. I believe for mining engineering we are in a crisis and a crisis is an opportunity; petroleum engineering departments appear to be in better condition but still face enrollment challenges. My testimony will be focused on academic mining engineering departments.

Introduction

The growth of economies is based in large part on our ability to extract mineral resources, in efficient and environmentally sound ways, at ever-lower costs. The ability to extract resources, increasingly in a situation of "the best of what is left", requires a specialized technical and managerial mining workforce. This workforce may now have a smaller population than many species on the US Endangered Species List. The academic mining engineering workforce especially meets the definition of a species in danger of extinction throughout all or a significant portion of its range.

The closure of the US Bureau of Mines, the lack of a long-term government minerals or energy policy, and the lack of respect and interest shown in minerals engineering programs by US universities are all contributing factors to the decline of academic mining engineering departments, low production of BS, MS, and Ph.D. level graduates, and lack of qualified faculty.

The mining business is "graying," with the great majority of current workers approaching retirement in the coming 10-15 years, and few younger workers entering the business. Nowhere is this fact more evident than in the professional ranks underpinning the industry. SME statistics are instructional.[1] The portion of members over 50 years old will soon exceed 60%, with the number of new professional level entrants almost insignificant—less than 4% of the 2003 membership is younger than 30 (Silver, 2004).

An example of the extent to which the age profile of mining professionals is advancing can be gained by examining the ranks of the geoscientists (geologists, geophysicists, metallurgists, and mining engineers) employed by the U.S. government. Around 2500 of these professionals are employed by the various federal agencies, with around 60% in the Department of the Interior. Just slightly under half (49.4%) of these individuals are currently over the age of 50, and a quarter of the (25.5%) over 55. The demographics for

[1] Society for Mining Metallurgy and Exploration, Inc.

the subset holding positions as mining engineers—a more direct indicator of the situation facing the U.S. mining industry—are identical.[2]

The convergence of these two trends—the approaching retirement of the experienced mining cohort and lack of young people entering the industry—has a major negative implication for mining companies. The opportunities to transfer experience from the older to the younger generation has been seriously impaired.

We are losing our technical mineral resource workforce, especially our academic mining engineering workforce, in this country and we do not have a global surplus on which to draw. Once you lose your capability to educate a technical workforce you do not easily regain it. We are on the verge of losing that capability in the US and I thank this Subcommittee for their interest and advocacy.

Factors that Lead to Closure or Decline of Academic Mining Engineering Programs

Enrollment

The University of California Berkeley, University of Illinois, Ohio State, University of Minnesota, University of Alabama, University of Idaho, Columbia University, University of Pittsburgh, Texas A&M, University of Washington, University of Wisconsin – Madison and Platteville, University of Wyoming have all closed their mining engineering programs since 1985, most on this list have closed since I made the decision to enter academia in 1987. Michigan Tech is in the process of closing their mining engineering program, South Dakota School of Technology closed their program recently and are now reopening it as mining and engineering management. Of the remaining 12 accredited mining engineering programs, 9 have a faculty size of 6 or fewer tenure track professors, all have a faculty size less than 10, four did not graduate any MS or PhD students in 2002, and five programs combined to graduate only ten PhDs in 2002 (data from SME Guide to Minerals Schools).

The 2003 SME Guide to Mineral Schools listed 10 mining engineering departments reporting undergraduate enrollments of 459 for an average of 46 per program. There were 66 tenure track faculty listed in mining engineering in 2003. This means the average student/professor ratio was only approximately 7:1. At the University of Arizona, the expectation is a student/faculty ratio of 22:1, with some non-technical degree programs having a ratio as high as 100:1.

The first factor leading to declining support and closure of mining engineering programs is student enrollment.

The 2001 "Report on the Status of Academic Geoscience Departments" published by the American Geological Institute (AGI) states, "From 1983 to 2000 there has been a 66.8% decline in geoscience enrollments. In 2001 there was a slight increase in the

[2] Source: NIOSH, March 2004.

undergraduate enrollments over 2000 levels, from 10,473 to 11,104 – a 6% increase. "(AGI, page 1, 2001)

"No other physical science discipline is as tied to such a variety of real-world factors as the geosciences. Consider that the following conditions all affect the enrollments and employment of geoscientists: 1) national interests and security -including the price of oil, the price of metals and strategic minerals, access to global markets, and levels of federal funding; 2) informed national awareness - including assessment, mitigation, and remediation of hazardous waste sites, ground water, and geohazards; and 3) population demographics - including the aging of the population, and the current and future composition of the workforce by gender, ethnic-minority status and citizenship. Of these three categories of change agents, only the last - demographics – is reliably predictable." (AGI, page 13, 1999)

"We can say with confidence that geoscience enrollment levels are controlled directly by employment opportunities." (AGI, page 13, 1999) We see a strong correlation between the price of copper and our enrollment at the UA in Figure 1.

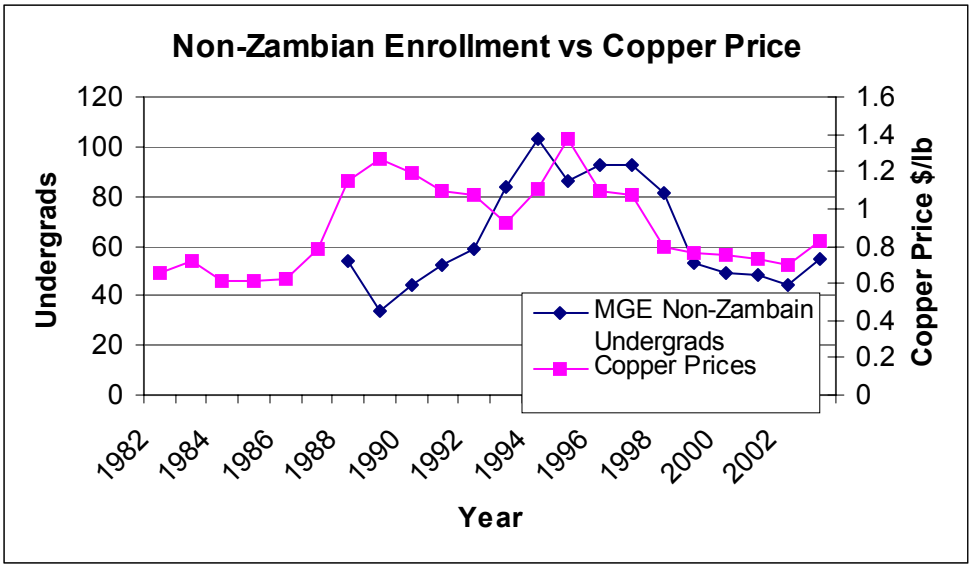

Figure 1. The correlation between copper prices and non-Zambian undergraduate enrollment in MGE at the UA shows that enrollment increases are out of phase with price increases but in-phase with price decreases. It takes a period of time before increases in price lead to increases in production and therefore increases in hiring whereas price decreases often necessitate rapid decisions about economic viability of mines and productivity of the labor force. Increases in production are seldom accompanied by media attention but decreases in production generate a lot of negative attention. The up tick in enrollment in 2003 is being driven more by demand in construction materials and heavy construction than hiring in metals mining.

An illustrative measure of the size of the problem facing industry is the number of students participating in undergraduate mining engineering programs, as surveyed in

SME's Annual Guides to Mineral and Material Science Schools. As shown in Figure 2, these enrollments, which stood in the 800 to 1,200 students in the 1950s and 1960's, shot up to nearly 3,000 when the extent of the 1970's global energy crisis became apparent[3]. This was followed by the precipitous in student numbers as commodity prices collapsed, energy concerns receded, and domestic mining became a socially disapproved endeavor during the 1980s. By 1990 the annual number of undergraduates pursuing a mining engineering degree had dropped to around 450, a level which continues today.

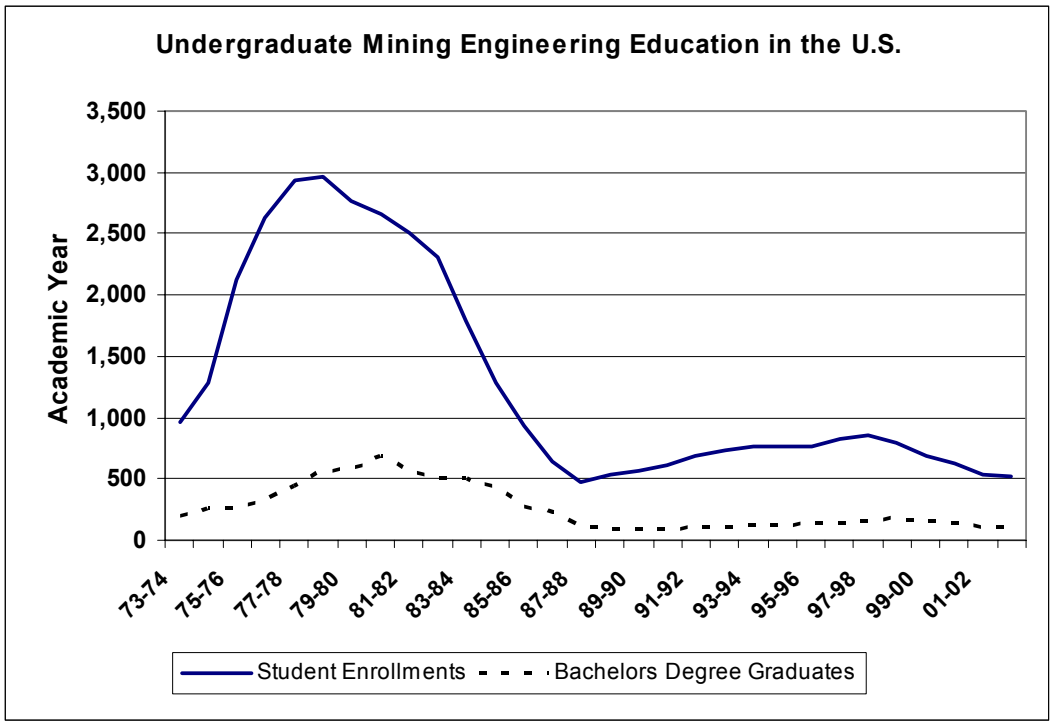

Figure 2. Historical enrollment trends in mining engineering. Source: SME Guide to Mineral Schools.

The number of annual Bachelor's level mining engineering graduates shows a similar trend: from the around 200 per year in the 1950's and 1960's, to the high of almost 700 in the early 1980's, to today's level of less than 100 per year. It should be noted that Masters and Doctoral degrees have followed similar paths, and, further, that this experience is not restricted to the United States. Numbers of enrolled students and graduates have decreased at mining schools throughout the world in this same timeframe.

The low undergraduate enrollments are related to the historically cyclical nature of industry hiring and layoffs and the pervasive education and public message that mining harms the environment and no respectable person should consider such a career. Our service-based economy has produced generations of students who view jobs involving physical activity and jobs in anything related to manufacturing or heavy industry to be

[3] Mining engineer demand expectations were driven not only by projections in the coal and shale oil sectors; forecasted scarcity of metal commodities and price spikes increased demand for mining specialists throughout the extractive industries.

low-class. We have become a "clean hands society" where only work in an environmentally controlled antiseptic indoor environment is valued. A pervasive public perception that "mining is dead in the US" because of government policy, nuisance lawsuits, and environmental impact investigations with no clear endpoint for decisions discourages students in the western US from pursuing a career in mining. I note that the mining engineering programs in the most jeopardy are located in the west.

In contrast to the situation in the US, the October 2003 issue of the Canadian Mining Journal (CMJ) reported that enrollments have increased in Canadian mining schools during the fall 2003 term (O'Hara, 2003). Some of that enrollment increase can be attributed to a strong minerals base in Canada, especially in diamonds, oil sands, base, and precious metals and strong statements of support from the government regarding the importance of mining to Canada's economy. The CMJ article reports that Canadian enrollments fall short of replacing retiring mining engineers over the next 10-15 years (pg 21). The article states "Ten years after graduation 50% of mining engineers are no longer involved with the mining industry; the remaining 50% are split equally between the mining industry and the mining service sector, according to Professor Jamie Archibald of Queen's." (pg 21-22) Hence, we have to account for attrition in the industry when we estimate the future demand for mining engineers.

University Economics

Of the 12 accredited mining engineering programs in the US, only 6 are at Carnegie Foundation classified Research Extensive universities (Arizona, Kentucky, Penn State, Utah, Virginia Tech, West Virginia). Of these six institutions, only Penn State and the University of Arizona were ranked in the top 20 of public universities by NSF for research expenditures in 2000. US Ph.D. granting universities have experienced substantial declines in the level of state support, which has forced many of them to shift their base of support from state revenues to overhead on research contracts and tuition. At the institution level, increases in tuition can help offset the lack of state dollars. Unfortunately at many institutions, tuition revenue does not flow to the college or department level (this might be a good thing when enrollments drop in a program and therefore tuition revenue for that program drops). Budget cuts, however, are implemented at the college and department levels. So, mining programs have been caught in a situation where enrollment declines have driven up their cost per degree and the present level of Federal, State, or industry research funding for minerals has not been sufficient to offset the budget cuts.

As US universities have become more reliant on Federal research dollars for primary support of their programs, faculty-hiring decisions are increasingly made based on where Federal support is available and likely to be available over several years. Since the closure of the US Bureau of Mines, the funding for mining research has been very limited and therefore the motivation to hire faculty in an area with limited prospects for Federal research funding has been negligible.

The second factor leading to declining support and closure of mining engineering programs is the change in university economic drivers.

Universities typically look at several key metrics to determine the productivity and cost of academic programs. Students are usually counted as full-time equivalents (FTEs) rather than as warm bodies. At the University of Arizona, 12 student credit hours (SCHs) constitute one FTE student. So, the total number of student credit hours is divided by 12 to determine the number of FTE students. In Arizona, every 22 FTE students justify the employment of one FTE faculty member. With an average student:faculty ratio of 7:1 for mining programs across the US, virtually no mining program in the US can justify more than 2-5 faculty members in mining with current enrollments. Compounding this problem is the fact that many universities view departments with less than 10-12 faculty members to not have sufficient critical mass to justify existence as an independent department as opposed to a program within another department. Mining programs that have been merged into other departments have historically closed, and closed quickly, as retiring and departing faculty positions are filled by the larger department rather than in the smaller mining program.

Universities calculate cost per degree, cost per student, and cost per SCH based on the department budget divided by degrees granted, by students in the program, or by SCHs generated. Mining programs are often high cost because the denominator (number of degrees, students, or SCHs) is low.

External Research Funding

The limited sources of competitive research funding for minerals-related research (e.g. NSF, DOE, DOD, EPA, NIH, NIOSH, etc.) make the metric of research dollars per faculty lower for mining engineering departments than other engineering programs.
At large research universities the expectation in colleges of engineering for external research funding is on the order of $150,000 - $200,000 per faculty member per year.

There have been several studies published in recent years by the National Research Council identifying promising and important areas of research in the mineral resources arena. There is not a shortage of needs identified by professionals in the resource industries. To date, however, there has been little or no support from the government for mineral resources research.

The third factor leading to declining support and closure of mining engineering programs is the lack of Federal research support.

The US Bureau of Mines (USBM) was created in 1910 and conducted research and collected information concerning almost every activity involved in recovering minerals from the earth, making them into useful products, and recycling materials for future use. The Bureau was closed on March 30, 1996. “Whereas all of the affected processes once resided in a single agency, citizens will now have to search through a multitude of federal organizations to obtain mining and minerals information.” (“A posthumous commentary

on the USBM" source: http://www.agiweb.org/gap/legis105/tpgusbm.html). Some USBM functions were transferred to the USGS, DOE, and NIOSH. The fragmentation of all the government responsibilities related to the minerals industry appears to be confusing, inefficient, and perhaps not very cost effective. But perhaps, more importantly, the fragmentation has decreased the power, the visibility, and the prestige of mineral resources related programs in the eyes of academic administrators.

The USBM Mineral Resources Research Institutes and Generic Research Centers were an important source of research support until the closure of the Bureau. In FY1994 the USBM funded $52M in research related to health, safety and mining technology (source: http://www.nap.edu/openbook/NX006653/html/20-26.htm). While much of this supported USBM research centers a substantial portion was allocated to university research.

Sources of Federal funding directed to minerals research are largely contained within two programs, the Department of Energy (DOE) Industries of the Future program and National Institute of Occupational Safety and Health (NIOSH). Faculty can submit proposals to the National Science Foundation (NSF) Division of Civil and Mechanical Systems Geotechnical and Geohazards Program but this program has very limited funding and any mining related projects tend to be focused in the area of geomechanics. The experience of mining engineering faculty is that any proposal submitted to NSF that focuses on mining engineering will not get funded. This raises the question in university administrator's minds that if an entire engineering discipline like mining engineering is of no interest to the nation's premiere funding agency of engineering research, why should the university continue to invest in such a program.

The DOE IOF program within the Office for Industrial Technologies funds approximately $4M for each mining roadmap (source: http://www.oit.doe.gov/mining/pdfs/miningbro01.pdf). Research proposals submitted to this program must demonstrate substantial energy savings as a result of the research. Most proposals require partnership with national labs and substantial cost sharing with industry partners. Each roadmap has a different emphasis. While the IOF program for mining is an excellent program, the roadmap approach makes it impossible for faculty to acquire funding for development of long-term research projects or more blue-sky projects. Furthermore, $4M divided among universities, national labs, and industry is insufficient to sustain one academic mining engineering department let alone 12.

The NIOSH funding for mining emphasizes health and safety issues in a broad context. The program managers for mining within NIOSH have been very pro-active in working with faculty at various universities. Longer term funding is available but limited. NIOSH is a critically important source of funding for several mining engineering programs, including the University of Arizona, and it is important that the NIOSH programs that support mine safety and health research be increased.

Funding within the US Geological Survey (USGS) for university research is extremely limited and is largely directed to economic geology programs. The MERIT (Mineral

Education and Research Initiative) program proposed by John Dilles, Mark Barton, and Larry Grayson among others proposes that $20M be added to the USGS Mineral Resources appropriation to fund a competitive grants program in applied mineral resources research and materials flow accounting. It should be noted that while the bulk of this testimony is focused on mining engineering, if current trends continue, within two decades there may be fewer than ten universities in the U.S. with *any* geoscience faculty working on mineral deposits (down from greater than fifty in 1980) (Barton, Pers. Comm.). Economic geology programs are in serious decline within geoscience departments for the same reasons mining engineering departments are closing.

Because of the very limited availability of Federal money for minerals-related research faculty must spend more time cultivating sources of funding from non-traditional sources, from international sources, and from industry. The development of these sources takes time, can be unstable, and sometimes is not credited equally with Federal funding by review committees within universities.

The importance of Federal research funding to the sustenance of academic programs in the US cannot be overstated. Universities decide their future directions, hiring plans, and new buildings based on availability of these funds. Faculty members hired today because of huge National Institutes of Health (NIH) or Nanotechnology Initiative budgets can expect to be employed by a university for 30-40 years if they are granted tenure. Hence there will be tremendous pressure to retain funding levels for research in the fields that are currently receiving large budgets in focused areas. Conversely, the sustained lack of Federal research support in any engineering or science discipline provides a strong incentive for universities to close those programs.

The lack of significant Federal funding for minerals related research puts pressure on nearly every mining engineering program at Research Extensive universities. It is imperative to retain these programs in particular because the interdisciplinary nature of the problems encountered in mining often require teams of researchers from the broad cross section of disciplines only found at Research Extensive institutions. We cannot, however, afford to weaken or lose any additional mining engineering programs in the US.

Prestige and Visibility

Minerals programs are not listed in any of the respected and well-read, professional and scientific or even popular surveys, including those conducted by NSF, ASEE (American Society of Engineering Educators), US News and World Report, etc. As a result serious questions are often asked in the academic administrations of universities regarding the need for sustaining or preserving mining engineering programs and most definitely the need for investing new resources in these programs (Karmis, 2002). University administrators value programs that they are told are valuable; either through external survey rankings or based on quantity of government research funding available. University administrators, have therefore, gotten the message that mining engineering programs are not valuable to the US.

The fourth factor leading to declining support and closure of mining engineering programs is the lack of any public message regarding value of these programs.

Estimates are that nearly 30% of the current faculty positions in mining engineering in US universities may be vacated in the next 5 years due to retirements. Most universities now sweep vacant faculty positions at the college or university level in order to reallocate precious positions where the return on investment is perceived to be greatest. This means that no mining engineering department can guarantee that a retiring mining professor will be replaced. Even at universities where the president, provost, or dean are not openly hostile to the notion of offering a mining engineering degree, they view their mining engineering departments as the lowest priority for resources and a poorer return on investment relative to larger engineering specialties like electrical or mechanical engineering. University administrators evaluate return on investment (faculty positions, space, start up costs, and operations costs) in the currency of overhead dollars on research contracts, papers published, PhDs produced, and national ranking in surveys. All of these currencies are directly and indirectly related to Federal research funding priorities and the visibility the Federal government places on different research disciplines. The decision-making and budgeting process implemented by public research universities, driven largely by severe financial pressures, is resulting in the dismantling of a mineral resources research and education infrastructure developed over the last 50 years. The resolution of short-term university budget crises by crippling or closing mining engineering departments can have severe implications for the US economy and security. I reiterate that the growing replacement of state support with government research contracts results in a near-Pavlovian response between Federal research priorities and support directed by universities to academic departments.

So, the fundamental drivers in closing mining engineering departments are related to low undergraduate enrollments that make the cost of the programs expensive, the decreased state support for public universities, the lack of research funding, and the desire by universities to redirect faculty positions and support to disciplines heavily subsidized by Federal research funding or that are nationally visible in survey rankings.

A crisis is an opportunity. Thanks to this Subcommittee the aging workforce has been publicly acknowledged as a potential crisis. The emaciated state of our mining engineering departments in US universities, especially our research universities, provides us with an opportunity to develop a new model of partnership between academia, Federal agencies, and industry. At the University of Arizona we are attempting to develop the largest interdisciplinary group focused on mineral resources research and education in the US. The USGS is expanding their presence at the University of Arizona and USGS scientists are offered adjunct professor appointments within the university. Laboratory facilities are shared between USGS and UA faculty. USGS personnel teach university classes and supervise graduate student research. The Geosciences Department is the primary beneficiary of this relationship but it has drawn in other departments now such as Hydrology and Water Resources. The partnership lacks a strong enough engineering component because there is no minerals-related agency focused on engineering comparable to the USGS.

Recommendations

I suggest five major action items for this committee to support (in rough order of importance) to stave off the crisis in mining engineering and to ensure that we have vigorous and respected academic mining engineering departments.

1. The importance of academic mining engineering programs to the US economy and to national security needs to be conveyed to the governors, university presidents and college deans that have existing mining engineering departments. There must be dialogue between national, state and university leaders to find ways to ensure the remaining mining programs not just survive but can thrive. This dialogue must happen soon.
2. Federal research funding for minerals-related research needs to be dramatically increased. Much basic research needs to be conducted in several areas including sustainable development, information technology, automation, low-impact extraction, advanced sensor technology and biotechnology to name just a few areas. Centers of Excellence in Mineral Resources should be developed at the existing research extensive universities and funded at a level sufficient to satisfy the metrics of each university and to develop a quality pool for the future professorate. Such centers can leverage existing funding such as the Center for Advanced Coal Mining Technologies at Virginia Polytechnic University or the USGS expanding presence at the University of Arizona.
3. A study by the National Research Council of the National Academies of Science should be commissioned to gather data on the existing mining and petroleum engineering programs, industry demand forecasts, workforce issues, and any other issues pertinent to making recommendations that will be implemented. A prospectus for such a study has been developed and reviewed by the NRC Committee on Earth Resources.
4. A strong and positive national public message needs to be conveyed by this committee that mining is essential, that those that work in the minerals industry are valued members of our society, and that mining engineering is a career choice that should be encouraged for our young people. It is urgent that the message that mining engineers are in critical shortage and essential for the well being of the US economy be conveyed at a national level by this subcommittee.
5. A national mineral resource strategy should be developed that includes policies that allow the US to continue to produce mineral resources in an environmentally sound and profitable manner. The current distribution of responsibilities for mineral resources management within the Federal government should be examined to determine if it is an optimal structure to support the sustainable development of our mineral endowment. We may find that a National Mineral Resources Foundation could be effective at coordinating a roundtable of representatives from all the appropriate Federal agencies, universities, and industry and advising Congress.

I want to thank this Subcommittee for giving me the opportunity to speak today. As paraphrased from the Rand 2001 report, the goal of this Subcommittee should be "Getting people to think and think together" (Peterson et al., 2001) in order to develop a long-term strategy to maintain an adequate technical workforce, academic base, and financially healthy minerals industry in the US.

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