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From Guncotton to Bakelite—The Early History of Polymer Science

PAUL C. PAINTER, *Associate Professor of Polymer Science*

"He fixed thee mid this dance
Of plastic circumstance"
ROBERT BROWNING.

Our most enduring images of the industrial revolution of the nineteenth century are perhaps those provided by the ironmasters and engineers. We think of a world of railways and factories, the social and political consequences of the division of labor, and the creation of an urban working class.

It is the world according to Charles Dickens, a society that in retrospect seems to have been built on iron, steel, and coal. Natural polymers in the form of cotton and rubber were, of course, key materials. However, the late nineteenth century also saw the introduction of synthetic and semisynthetic plastic materials that had a profound social and economic impact.

The effect of these new materials was not as dramatic as the structures built of iron. How can you compare a molded lavatory seat to the Forth bridge? Nevertheless, plastics had a direct impact on the daily lives of people. They also had the disconcerting economic characteristic of becoming cheaper, not more expensive, as demand grew.

An Accidental Discovery

In 1845, common household objects such as combs and toothbrushes were usually laboriously fashioned from bone or ivory

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"Continuous Mining," an original color woodcut by Antonio Frasconi. From the College of Earth and Mineral Sciences collection of art depicting the mineral industries.

Mineral Economics—A Mature Profession

WILLIAM A. VOGELY, *Professor and Head, Department of Mineral Economics*

Three and one-half decades ago, The Pennsylvania State University established the first Department of Mineral Economics at an American university, in fact, at any university in the world.

The department was established because of a belief, since borne out by events, that the issue of mineral resource availability would be one of increasing importance to the nation and to the world.

The world was just emerging from the second worldwide war of the century. The fighting of that war had consumed vast amounts of mineral and energy resources. The strategy and issues underlying the events leading to World War II were being analyzed and explained in terms of geopolitics that had as its base the necessity to control resources to sustain an industrial society. In 1946, The Pennsylvania State University picked up on an interest in mineral economics which had flared briefly in the early 1930s and began the development of a profession which has now reached maturity.

The Beginnings of Mineral Economics

In the 1920s, the title "mineral economist" was first used by the Bureau of Mines and a number of mineral scientists, largely mining engineers and economic geologists, began to devote some of their time to mineral economic issues. The Brookings Institution in Washington, D.C., developed an interest in the little known

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Efforts through Required Training to Improve Coal Mining Health and Safety

JAMES D. BENNETT, *Director*
Mining Continuing Education Services

The Department of Energy, in its 1978 annual report to Congress, predicted that bituminous coal and lignite production would reach 1.033 billion tons by 1985 and 2 billion tons by 1995. This compares with 697 million tons produced in 1977.

Employment in bituminous coal and lignite mining was 221,000 in 1977.[1] This work force is expected to increase to 274,000 (a 25-percent increase) in 1985 and to 441,000 by 1995 (a 100-percent increase).[2]

These projected employment and production increases, coupled with the current United Mine Workers of America contract, which makes it possible for miners to retire at age 55, have created a tre-

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Polymer Science—

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and thus were unavailable (except in a crude wooden form) to most people. This was to change, though not immediately, with the work of C.F. Schoenbein. According to legend, he was working on nitration reactions when his flask broke, spreading nitric and sulphuric acid on the floor. He used his wife's cotton apron to mop up the mess and then hung it to dry in front of the fire. After the smoke had cleared, it was apparent to Schoenbein that he had discovered a new explosive, which became known as guncotton. During the Napoleonic wars, battles had been characterized by the dense smoke produced by gunpowder. Guncotton was considered a major advance because it produced less smoke and generals were now able to see the people they were slaughtering.

Fortunately, there was also interest in nitrated cellulose as a material for other, more peaceful purposes. It was discovered that at levels of nitration less than 13 percent the material is flammable but not explosive. A French chemist, Louis Menard, found that it could be dissolved in an alcohol and ether solvent and thus formed into a transparent film, called collodion, which was used as dressing for cuts and wounds. However, the first use of nitrated cellulose as a material for making everyday objects can be attributed to an Englishman, Alexander Parkes.

Parkes was a true materials scientist and, prior to his work on polymers, had achieved considerable fame as a metallurgist. He was born and did most of his work in Birmingham, a city that can be loosely described as the Cleveland of England. In this industrial environment, he quickly learned how to profitably apply his scientific discoveries. His ideas were incorporated in no less than eighty patents, but his energy and fertility were not confined to the pleasures of the mind, for he was also the father of twenty children.

Parkes' major contribution to polymer science was the discovery that when castor oil and camphor were added to nitrated cellulose, the material would soften at a reasonably low temperature and could be molded. He modestly called this material Parkesine and it won a medal at the Great Exhibition at the Crystal Palace in 1862 for excellence of product. Parkes seems to have been unaware of the special role of camphor as a plasticizer. In some of his published formulations he omitted reference to it completely, and the commercial exploitation of Parkesine was ultimately a failure, but nonetheless marks the beginning of the plastics industry.

The story now shifts across the Atlantic where the next development came as a direct consequence of a world shortage of elephants and rhinoceroses. It is a classic case of a short supply of one material, namely, ivory, providing the impetus for the development of another. The American billiard ball manufacturing company, Phelan and Callendar, offered a prize of $10,000 to anyone who could invent a substitute for ivory billiard balls. John Hyatt took up the challenge and chose to experiment with Parkesine. One can speculate that Hyatt had misspent his youth in pool halls because he was intrigued by the problem and spent several years of his life working towards a solution. He did not win the prize, but did establish the Albany Billiard Ball Company which used a mixture of gum shellac and pulp to make the bulk of the ball. This was coated with nitrocellulose, which gave the new billiard ball some interesting properties. Hyatt later reported that "we had a letter from a billiard saloon proprietor in Colorado mentioning that occasionally the violent contact of the balls would produce a mild explosion and saying that he did not care so much about it, but that instantly every man in the room pulled a gun."

Celluloid Is Developed

This experience with nitrocellulose prompted Hyatt to investigate its properties in more detail . He eliminated castor oil from his formulations, using only camphor and, with good old Yankee ingenuity, finally solved the manufacturing problems that had plagued Parkes. He produced a hard material that could be softened by heating to about 90°C and called it celluloid.

Celluloid was a tremendous success. Many common objects that were previously expensive because of the cost of available raw materials and the skill and time required for shaping them could now be mass produced cheaply. It is possible to list numerous objects ranging from knife handles to false teeth, from combs to that symbol of Victorian morality, the stiff celluloid collar.

Celluloid was not, of course, a true synthetic but rather a chemically modified natural polymer. Its central significance to the development of the true synthetics was not the nature of the objects produced, even though these had an important social and economic impact, but the engineering techniques and machines developed to produce these goods. An example is the artificial silk fiber produced by Count Hilaire Chardonnet. He developed an extrusion process in which a nitrocellulose solution was forced through a small orifice producing a lustrous thread upon evaporation of the solvent. Unfortunately, nitrocellulose lost none of its hazardous incendiary qualities in this process. The workers in Chardonnet's factory quickly dubbed the product "mother-in-law silk", thus revealing an interesting though morbid sense of humor.

The present-day processes for manufacturing fibers were further refined after the introduction of regenerated cellulose in 1892. Cellulose itself is insoluble, but many of its derivatives are soluble. Consequently, it became common practice to process a solution of a cellulose derivative and then remove the modifying groups. The subsequent material is known as regenerated cellulose. It is nice to note in passing that William H. Walker, a Penn State graduate in the class of 1890, together with Arthur D. Little, developed manufacturing processes for both yarn and film. Fibers from regenerated cellulose were called rayon while films were known as cellophane

An aspect of the early plastics industry that has an interesting parallel to our present energy situation was the use the Japanese made of their camphor monopoly. Between 1868 and 1907, the price of this essential ingredient rose from 7-½ cents to 76-½ cents per pound and eventually peaked at $4 per pound in 1918. It proved commercially infeasible to grow camphor trees in this country, but fairly expensive methods for producing synthetic camphor were developed. However, as soon as plants for the production of this plasticizer were built, prices were dropped, bankrupting the companies in-

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volved. It must be admitted that the Japanese played the market in a masterly fashion and that they could probably give Sheik Yamani lessons in economic manipulation. However, financial pressure finally resulted in the development of synthetic plasticizers, helped somewhat by the extraordinary institution of prohibition. Diethyl phathalate has proved to be an effective plasticizer but was first produced as a denaturant for alcohol.

The First True Synthetic Plastic

Economic life at the turn of the century seems to be characterized first by a strange mixture of almost Darwinian free enterprise and monopoly capitalism and second by the introduction of new industries based on the discoveries of a remarkable series of inventors and innovators. Perhaps the most famous is Edison, but the discoveries of Leo Baekeland were almost as far reaching. Despite the legends that have subsequently surrounded these men, they did not work in a vacuum but built on previous work. For example, Joseph Swan produced an electric light bulb twenty years before Edison, but failed to obtain a vacuum effective enough for the bulb to function for an adequate length of time. Similarly, Baekeland's synthesis of the first true synthetic plastic built on the work of Adolf von Baeyer. Rather than casually discarding the insoluble messy gunk that was often the result of nineteenth-century chemical tinkering, Baekeland investigated the conditions that would enhance their production. Using phenol and formaldehyde in the correct proportions, he eventually produced a thermosetting plastic that was named Bakelite. This true synthetic plastic could be molded into practically any shape and was an excellent electrical and thermal insulator. If it was brittle and tended to break when dropped, it was also cheap and easy to replace. To many people the discovery of Bakelite marks the birth of the true plastics industry and the reputation of plastics as being cheap substitutes for natural materials such as wood.

Polymer Science Comes of Age

Even with the introduction of superior plastics, the arguments surrounding natural versus synthetic materials remain, often based on emotional fervor and a lack of real knowledge. However, there have always been elements of irrationality associated with new materials and it would be unrealistic not to expect some difficulty in extricating polymer science from the pit of antiknowledge. In fact, the concept that the new plastics, as well as rubber and cotton, consist of large molecules or polymers was not established until the 1920s. As von Baer once remarked, every triumphant theory passes through three stages; first it is dismissed as untrue; then it is rejected as contrary to religion; finally it is accepted as dogma, and each scientist claims that he had long appreciated its truth.

Herman Mark, one of the fathers of polymer science, states that two of the historical milestones in the arguments surrounding the putative existence of macro-molecules were meetings in Dusseldorf in 1926 and Cambridge in 1936. At the Dusseldorf meeting, polymer science can be said to be at von Baer's first stage. In fact, the meeting was set up to confront Staudinger, one of the chief proponents of

Dr. Richard Hogg, left, professor of mineral processing, and Dr. Lloyd A. Morley, center, professor of mining engineering, received the 1980 Wilson Outstanding Teaching Awards of the College of Earth and Mineral Sciences. Making the presentation is Dr. C. L. Hosler, dean of the college.

Drs. Richard Hogg and Lloyd A. Morley Receive 1980 Wilson Outstanding Teaching Awards

Dr. Richard Hogg, professor of mineral processing, and Dr. Lloyd A. Morley, professor of mining engineering, have received the 1980 Matthew J. and Anne C. Wilson Outstanding Teaching Awards of the College of Earth and Mineral Sciences.

Presentation of the awards, each of which consist of $1,000 and an engraved plaque, was made at the college's 12th annual student and faculty awards dinner last spring.

First presented in 1968, the Wilson Awards are made possible by the Matthew J. and Anne C. Wilson Trust Fund which was set up in the will of the late Matthew J. Wilson, a 1918 Penn State mining graduate who died in 1963.

Dr. Hogg received his B.Sc. in ceramics from the University of Leeds in 1963, and his M.S. in ceramic engineering in 1965 and his Ph.D. in materials science and engineering in 1970 at the University of California at Berkeley.

In 1954-59, he worked as a laboratory assistant with Cleveland Magnesite and Refractory Co., Middlesbrough, England, and, in 1966-69, was an assistant specialist at the University of California at Berkeley. He joined the Penn State faculty in 1969.

He teaches courses in mineral particle systems, fine particle characterization, interfacial phenomena, particle/fluid dynamics, and general mineral processing. His research is concerned with fine particle technology, colloid and surface chemistry, and process analysis and modeling. He is a member of a National Academy of Sciences Committee on Communication and Energy Consumption.

Dr. Morley received his B.S. in 1968 and his Ph.D. in 1972, both in mining engineering from the University of Utah. He joined the Penn State faculty in 1971.

Active in the Industry Applications Society of the Institute of Electronic and Electrical Engineers, he served as chairman of the IAS Mining Safety Standards Committee in 1976-78, and is currently chairman of the IAS Mining Industry Committee. In 1979, he was chairman of this committee's technical conference.

He teaches courses in mine plant design, mine power system and communications design, and mine power system protection. He serves as director of Penn State's mine electrical research laboratory where his research has been in the area of mine electrical power systems, specifically, mine power system performance, prediction of power system failures, power system computer simulations, grounding systems, protective relaying, and electrical shock prevention.

the large molecule concept. However, by 1936, matters had progressed to von Baer's third stage. The ten-year period between these meetings saw the introduction of numerous new plastics, principally from the laboratories of I. G. Farben and DuPont. The synthesis of these materials was now based on chemical principles rather than empirical trial and error, and polymer science had come of age.

The second world war provided a tremendous impetus for the growth of the plastic industry. In particular, there was a tremendous industrial effort to develop and produce synthetic rubber, because natural rubber supplies had been cut off with the Japanese capture of the plantations of Malaya and the East Indies. However, these later trials, tribulations and developments merit an article in their own right, to be presented in a future issue. Suffice it to say that the explosive growth in polymeric materials has led many enthusiastic authors to refer to the "Age of Plastics," which presumably encompasses the past thirty years. Although it is pleasant to contemplate how this label must enrage the metallurgists and ceramicists, it is perhaps more accurate to conclude by noting that plastics have a range of properties that place them in a complementary fashion alongside metals and ceramics in the arsenal of the materials scientist.

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The Author

Dr. Paul C. Painter received his B.S. in 1968 and his M.Sc. in 1970, both at the University of London in England. His Ph.D. was awarded by Case Western Reserve University in 1975. He joined the Penn State faculty in 1976. His research interests are in Fourier transform infrared and Raman spectroscopy of polymers.

University-Industry Team Tackles Problems of Nuclear Waste Solidification for Safe Disposal

In an important step toward helping to solve the problem of nuclear waste disposal, scientists at Penn State and the Rockwell Corporation of Pittsburgh are combining their expertise to begin making and testing crystalline ceramic waste forms that they believe should be the best method of immobilizing dangerous nuclear wastes for millions of years.

With a first-year grant of $1.5 million per year from the U.S. Department of Energy, the scientists are working with ceramic or "synthetic mineral" waste forms that have been developed over the last few years at Penn State's Materials Research Laboratory (MRL).

"This project marks a significant development in the actual treatment of nuclear wastes," says Dr. Rustum Roy, MRL director and professor of the solid state, "not only because we're trying to move Penn State's science into technology, but because, in the project, two of the nation's major institutions involved in nuclear waste disposal are teaming up in a new type of joint venture.

"The nation is looking all over for ways to innovate more rapidly by coupling its universities to its industries," Dr. Roy continues. "For nearly 20 years, long before it was fashionable, Penn State's MRL worked actively to do just that. This contract is an excellent example of this. It was on the initiative of MRL that Rockwell Corporation was chosen to build on the science base in radwaste research established here at Penn State.

"Essentially, what we will be doing," Dr. Roy points out, "is taking the improved solid waste forms we have developed here right up through the hot-pressed phase. We hope to be able to solidify liquid and semi-solid nuclear wastes from reprocessed spent nuclear fuel, almost 100 percent from the weapons program, into highly insoluble ceramic forms by relatively simple processes.

"We also want to develop precise tools," Dr. Roy says, "to compare our artificial mineral or ceramic waste form with the 'glass' form which some nuclear nations have considered the most viable solution for solidification of spent nuclear wastes up to now."

In the Penn State process, radioactive atoms—radionuclides—are chemically immobilized in synthetic ceramic materials designed to mimic nature's most geologically stable minerals.

"The key to this innovation," Dr. Roy notes, "is that, unlike glass which doesn't exist below the surface of the earth in nature, our waste forms are patterned after highly stable minerals known to last for hundreds of millions of years, unaffected by their geological environments.

"In effect," the scientist says, "such ceramic waste forms already have been 'tested' by time. We know from mineralogical and geochemical studies that certain natural minerals can withstand certain combinations of pressure, temperature, water, and mechanical abrasion without breaking down chemically.

"What we've done, and now are continuing on a broader and larger scale, is to immobilize nuclear wastes, turning them into a form so inert that no geological events—such as weathering by water at modest temperatures and pressures, or earthquakes that might cause the entry of water—can lead the material to decompose and thus release radioactivity."

For added safety, he says, these manufactured "minerals" would be encased in a "mineralogically impregnable fortress" consisting of a series of metal and artificial mineral barriers which are also designed to withstand physical and chemical geological events. In the form of large canisters, this nuclear waste package would be buried 1,000 to 2,000 feet underground, most likely in granite, basalt, or shale, far below groundwater levels.

Three years ago, in what was a major discovery, Penn State scientists found water to be a crucial problem with spent nuclear wastes that were converted into a glass-like solid. They showed that if groundwater were to come in cotact with the glassy wastes, as then planned, during the first 100 years or so of their burial, the wastes would break down within a period of a few days to a few weeks.

"Because our synthetic minerals can stand up under this condition," Dr. Roy points out, "Rockwell and Penn State have been asked by the government to manufacture, test, and evaluate these minerals on a pilot-plant scale.

"Initially," he says, "we'll work with 'cold' atoms, nonradioactive isotopes of the 42 radioactive substances among which are uranium, cesium, strontium, and molybdenum. Before we begin working with 'hot' atoms, we must determine which synthetic minerals are best suited for each type of waste."

These wastes vary considerably, Dr. Roy explains, depending on such factors as their source—national defense or commercial, their age, and their chemical composition.

The Penn State scientists will be responsible, essentially, for designing and evaluating different waste forms, while Rockwell will concentrate on developing a manufacturing process that is simple, safe, and operated totally by remote control.

Scientists from Rockwell's Corporate Science Center and its Atomic International Laboratories in Los Angeles are now working with Penn State researchers whose primary interests are in materials science, geology, and nuclear engineering. Those from the College of Earth and Mineral Sciences faculty in addition to Dr. Roy are Dr. Della M. Roy, professor of materials science; Dr. W. B. White, professor of geochemistry; and Dr. D. K. Smith, professor of mineralogy.

Mine Safety—

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mendous potential for new employees in the mining industry.

This projected rapid development of coal production and the consequent doubling of the coal mine work force have created concern about the availability of a properly trained work force that is capable of producing coal safely and efficiently. The intent of this article is to review underground bituminous coal mine safety during the past decade and assess the effects on mine safety of the training required by provisions of the Federal Coal Mine Health and Safety Act of 1969, the 1974 United Mine Workers of America contract, and the Federal Mine Safety and Health Act of 1977. Finally, some concerns about the type of training currently required and its ability to provide a work force that can produce coal safely will be discussed.

The promotion of health and safety in the mining industry by the investigation of accidents and their causes, by research and development of special equipment, and by research into accident causes and prevention has long been an activity of the U.S. Bureau of Mines and, more recently, the Mining Enforcement and Safety Administration (MESA) and the Mine Safety and Health Administration (MSHA). The initial authorization establishing the U.S. Bureau of Mines had its origin in Public Law (P.L.) 6-197, passed in 1910. The major federal legislation governing safety in metal/nonmetal mining was P.L. 89-577, passed in 1966. Beyond the initial establishment of the U. S. Bureau of Mines, the Federal Coal Mine Health and Safety Act of 1969, P.L. 91-173, was perhaps the most significant event in attempts to improve mine health and safety.

1969 Coal Mine Health and Safety Act

In writing the 1969 Coal Mine Health and Safety Act, Congress declared in its investigative findings that the first priority and concern of all the coal mining industry must be the health and safety of its most precious resource—the miner. The purpose of the 1969 act was fourfold:

"... 1) to establish interim health and safety standards and to direct the Secretary of Health, Education and Welfare, and the Secretary of Interior to develop and promulgate improved mandatory health and safety standards and to protect the nation's coal miners; 2) to require that each coal mine operator and miner comply with such standards; 3) to cooperate with and provide assistance to the states in the development and enforcement of effective state coal mine health and safety programs; and 4) to improve and expand, in cooperation with the states and the coal mining industry, research and development and training programs aimed at preventing coal mine accidents and occupationally caused diseases."[3]

Congress recognized that, in order to effect a reduction in fatal accidents, education and training in safer work methods and new health devices was a necessity. As a result, it provided for:

"... the training of miners and operators in the recognition, avoidance, and prevention of accidents or unsafe conditions or unhealthful working conditions in coal mines; and in the use of flame safety lamps, permissible methane detectors and other means approved by the Secretary for detecting methane and other explosive gases accurately."[4]

Provisions were also made for assistance to operators in meeting the requirements of the act and for further improvement of the health and safety conditions and practices in coal mines.

It must be noted, however, that the provisions for education and training of operators and miners were not mandatory for hourly employees. The act only dictated that training in the aforementioned areas must be offered to miners—meaning hourly employees. The only training required was that for supervisors in the detection of methane, other explosive gases, and oxygen deficiency.

1974 United Mine Workers of America Contract

Historically, the next significant event with regard to coal mine health and safety was the National Bituminous Coal Wage Agreement of 1974, ratified by the United Mine Workers of America (UMWA) on December 6, 1974. Although the UMWA contract is not a federal mandate, it is a wage agreement that affects a great number of the nation's coal miners. At the time of its ratification, a majority of the total U.S. bituminous coal mine population was UMWA-affiliated and 61 percent of the nation's bituminous coal was produced by union coal miners.[5]

Article XVI of the contract, entitled "Training," marked the first time in U.S. coal mining history that it was made mandatory for any type of hourly-paid miner to attend a variety of training classes.

Additionally, the contract called for a Joint Industry Training Committee to consist of three representatives appointed by the UMWA and three representatives of the coal industry appointed by the Bituminous Coal Operators Association. This committee was to meet primarily for the purpose of fostering and providing for the advancement of effective training in

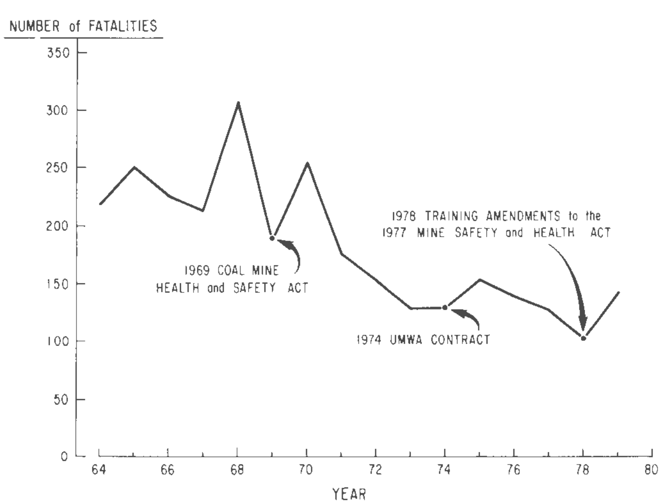

Figure 1. Bituminous coal mining fatalities from 1964 to 1979.

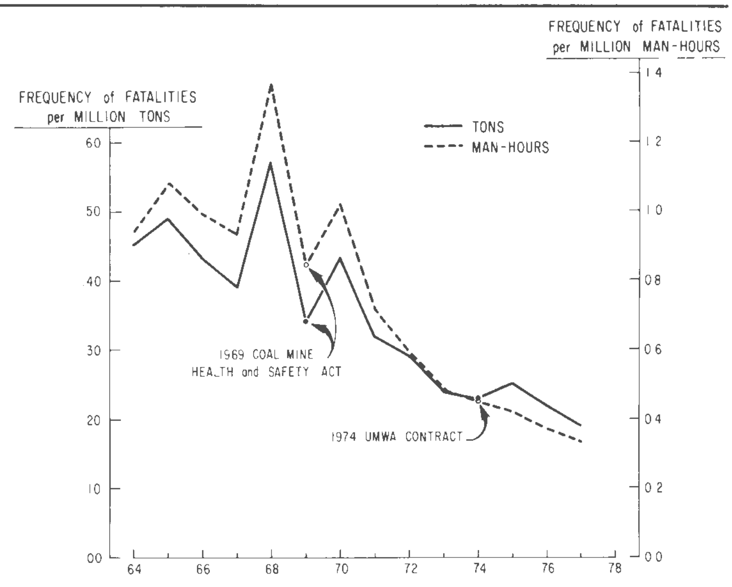

Figure 2. Frequency of fatalities in bituminous coal mining per million tons mined and per million man-hours worked.

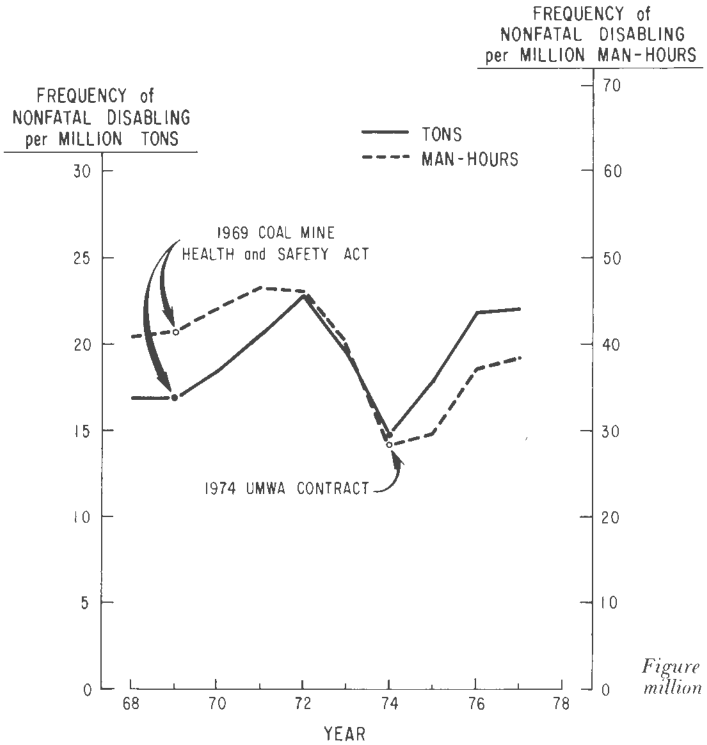

Figure 3. Frequency of nonfatal disabling injuries in bituminous coal mining per million tons mined and per million man-hours worked.

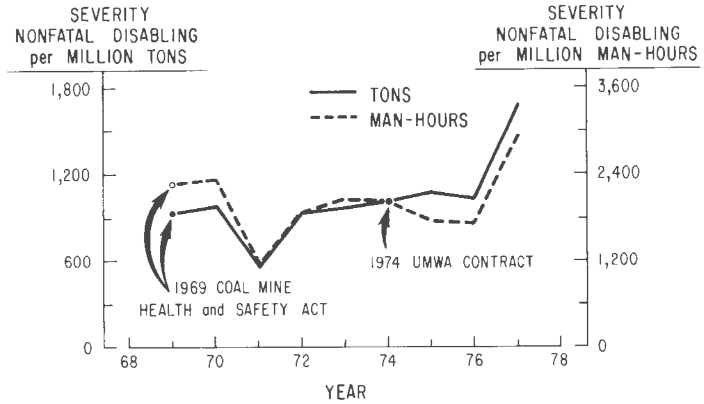

Figure 4. The severity of nonfatal disabling injuries in bituminous coal mining per million tons mined and per million man-hours worked.

the coal mining industry. It was to give special attention to smaller operators who did not have the capital and/or had not in the past developed training programs. The International Union of UMWA and the Bituminous Coal Operators Association each assigned a full-time training staff representative to the Joint Industry Training Committee to ensure the development and implementation of the training programs.

Article XVI contained provisions for four types of training: 1) orientation for new employees; 2) general retraining; 3) safety training for specific jobs; and 4) maintenance training.

1977 Mine Safety and Health Act

The most recent federal mandate in mine health and safety has been the federal Mine Safety and Health Act of 1977, P.L. 95-164, which amended P.L. 91-173. The impact of the 1977 act is not specifically in the areas of regulating and enforcing health and safety standards, but rather in mandatory health and safety training. Generally, the health and safety standards as outlined in the 1969 act remain unchanged. However, for the first time in U.S. history, health and safety training is now required for the entire mineral industry, both coal and non-coal. The training requirements are specified in the act under Section 115 where the law dictates that each operator of a coal or other mine must have a health and safety program which is approved by the Secretary.

The final regulations stipulate five types of training: 1) newly-hired inexperienced miner; 2) newly-hired experienced miner; 3) annual retraining; 4) task; and 5) hazard.

Each training program approved by the Secretary is to provide as a minimum that:

"... 1) new miners having no underground mining experience shall receive no less than 40 hours of training if they are to work underground. Such training shall include instruction in the statutory rights of miners and their representatives under this Act, use of the self-rescue and respiratory devices, hazard recognition, escapeways, walk-around training, emergency procedures, basic ventilation and roof control, electrical hazards, first aid, and the health and safety aspects of the tasks to which the miner will be assigned; 2) new miners having no surface mining experience shall receive no less than 24 hours of training if they are to work on the surface. Such training shall include instruction in the statutory rights of miners and their representatives under this Act, use of the self-rescue device when appropriate, hazards recognition, emergency procedures, electrical hazards, first aid, walk-around training and the health and safety aspects of the tasks to which the miner will be assigned; 3) all miners shall receive no less than eight hours of refresher training no less frequently than once each 12 months . . . ; 4) any miner who is reassigned to a new task in which he has had no previous work experience shall receive training in accordance with a training plan approved by the Secretary under this subsection in the safety and health aspects specific to that task prior to performing that task; and 5) any training required by 1), 2) or 4) shall include a period of training as closely related as is practicable to the work in which the miner is to be engaged . . . ."[6]

* * * * *

Penn State Provides New and Experienced Miner Training

A new miner training and experienced miner retraining program has been conducted by Penn State's mining continuing education services for the past five years.

James D. Bennett, the author of the accompanying article, directs this program.

Over this period, more than 10,000 Pennsylvania mine workers and supervisory personnel have received instruction mandated by federal law and the United Mine Workers of America contract.

Supported by an annual grant of about $250,000 from the federal Mine Safety and Health Administration (MSHA) through the Bureau of Deep Mine Safety of Pennsylvania's Department of Environmental Resources, this program currently includes 15 courses taught by six instructors.

The courses are offered as a service for, and at the request of various companies at no cost to them. Conducted at or near the mine sites, the courses are usually 8 to 40 hours in length. Penn State provides all the instructional materials and sees that the records required by MSHA are kept and given to the company upon completion of a course. The trainees receive various MSHA certificates according to the courses they complete.

* * * * *

Newly-hired experienced miners are those who have had less than 12 months' experience in the preceding three years. They must have either 40 hours of training (underground), or 24 hours (surface). A newly-hired experienced miner is one who has had at least a year's experience in the preceding three years and generally is a person leaving employment with one mining company to work for another.

Hazard training is required for non-operating mine personnel who must enter and remain on mine properties for specified periods of time for a variety of reasons. To be required to have hazard training, a person must: 1) not fit into any of the previously mentioned training categories; 2) enter and remain on a mine property on an irregular basis; and 3) in fact, be exposed to a hazard.

Sales and service people, technicians, and researchers make up the majority of persons who need to have hazard training. Since the mining operator is legally responsible for the health and safety of all persons entering the mine property, hazard training is the grandfather clause for persons not covered in other training categories.

The UMWA contract and the two federal acts philosophically benefit mine safety in two areas. First, the mining industry now has legal, enforceable health and safety standards governing the mine's working conditions and environment. Secondly, there are training and retraining provisions for all miners and all other people who must enter the mine property with any regularity.

Statistical Review of Coal Mine Safety

A statistical review of injury experience in bituminous coal mining from 1968 to 1979 reveals what impact, if any, has been made on mine safety by the two federal acts and UMWA contract.

(Note that in 1978, MSHA began using injury incidence rates representing the number of injuries occurring for each 200,000 employee-hours worked; in earlier years, the rates were based on each 1,000,000 hours worked.)

Figure 1 depicts bituminous coal mine fatalities from 1964 to 1979, indicating that there has been a general downward trend over this 15-year period. It is interesting to note that there were general increases in fatalities in every year following a major attempt at mandated federal or union training.

Figure 2 displays bituminous fatalities in terms of frequencies per million man-hours and per million tons. The trends for both frequency per million tons and frequency per million man-hours follow the same general downward trend that the general fatality record shows. These trends have been consistent although there has been a fluctuation in terms of total production for any given year and the average number of workers and employee-hours reported per year.

Figure 3 depicts frequencies of nonfatal disabling injuries per million manhours and per million tons. With the same fluctuations in production and employee-hours reported above, the trends for these two rates are similar. The nonfatal disabling (NFD) frequency rate per million man-hours has decreased slightly from 40.89 in 1968 to 38.14 in 1977. However, there has been an increase in NFD per million tons from 16.86 in 1968 to 22.09 in 1977.

Each accident is assigned a severity number determined according to a formula prescribed by MSHA. The severity rate for nonfatal disabling injuries, shown in Figure 4, has experienced a drastic increase. The severity rate per million man-hours has increased from 2,269 in 1969 to 2,901 in 1977. The severity rate per million tons has gone up from 923 in 1969 to 1,680 in 1977.

These figures indicate there has been a decrease in total fatalities and frequencies over the period studied, but the frequency of nonfatal disabling injuries has remained relatively constant or has increased. There also has been a downward trend in the frequency of nondisabling injuries (Figure 5). However, nonfatal disabling injury severity rates (both per milion tons and per million man-hours) have increased dramatically.

Although some improvements have been made in mine safety during the period from 1968 to 1979, the general trends indicate at best a leveling out or decreases at rates unacceptably slow to this author, and some data even indicates increases in accidents and severities. Obviously, there has been some positive impact on mine safety by the federal acts and the UMWA contract, but these mandates have only begun to build a base for the real safety and training work to be accomplished.

The statistics show that safety cannot be legislated—that merely setting standards and requiring miners to attend classes to learn about these standards is not enough.

Presently, most miners merely attend mandatory training classes with no measurement made of what they have actually learned. Occasionally, written exams are conducted, but seldom does a miner have to demonstrate the knowledge he has acquired. The most practical way to ensure that health and safety regulations are upheld is to have the trainees physically show that they can do what they are supposed to have learned in their classes. Professional educators call this approach competency-based education.

On the basis of the safety record of the U.S. coal mining industry during the past decade, there should be grave concern about the ability of this nation's future coal mine work force to produce coal safely. Perhaps competency-based education is the tool that will solve this problem.

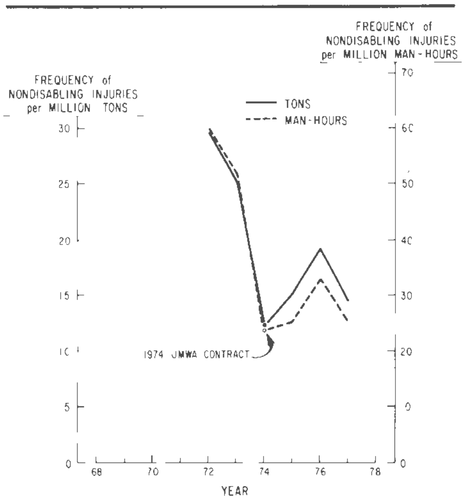

Figure 5. The frequency of nondisabling injuries suffered in bituminous coal mining per million tons mined and per million man-hours worked.

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The Author

James D. Bennett, who has a B.A. from West Virginia University and an M.A. from Eastern Kentucky University, joined the Penn State staff in 1974. He assumed responsibility for the mining continuing education program in 1977. In this role, he coordinates and oversees the more than 30 short courses in various mining topics offered each year, the Elders Ridge Mine Mechanics and Electricians School, and the new miner training and experienced miner retraining program described on page 66.

Mineral Economics—

Continued from first page

field, published a number of studies and granted a few degrees in mineral economics. The Washington group of government specialists who were members of the American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME) interacted with the then new Brookings Institution. This led to a series of public lectures jointly sponsored by Brookings and the Washington sections of AIME in 1931. Out of these lectures came the first book called *Mineral Economics*, published in 1932. The Depression turned the interest of scholars and the public to other issues, and the field waned until 1946 when the Penn State department was formed.

The first bachelor of science degree in mineral economics was awarded by Penn State in June 1947, the first M.S. in January 1948, and the first Ph.D. in June

1954. During this period, Penn State was the only separate mineral economics department in the world, although students could pursue the interest within other disciplines at the Colorado and Montana Schools of Mines, Massachusetts Institute of Technology, Columbia, Cornell, and Stanford Universities; and the Universities of Illinois and Minnesota.

After the first few years, interest in mineral economics at Penn State began to decline. The department shrank to less than a dozen undergraduate majors and a few graduate students. This decline in enrollment halted the spread of mineral economics as a discipline to other universities. It coincided, in fact, with the long decline, only recently reversed, in the mining departments of many universities.

In the early 1960s, Penn State undertook an intensive review of the Department of Mineral Economics, its staff, and its curriculum. This review was conducted by outside experts who came to the university and examined the program closely. They recommended that the program be continued and strengthened with the addition to the faculty of persons with professional economic training. They emphasized, however, that mineral economics as a professional discipline must maintain its emphasis not only on professional economics but also on the earth sciences and the related mineral sciences.

The interest in mineral economics was also increasing in the nonprofit research organizations and in the federal government. Following the appointment of the President's Material Policy Commission by President Truman, the U.S. Bureau of Mines established an Office of Chief Economist, and that office attracted to the Bureau economic professionals with a deep interest in mineral resources. In 1954, the Ford Foundation supported the establishment of Resources for the Future to undertake professional analysis of resources problems. Although Resources for the Future covered a broader area than mineral problems, much of the early work of that group was concentrated in mineral resources, and highly competent technical books on mineral economics began to appear on the bookshelves of the nation in the early 1960s.

With this revival of interest, the undergraduate enrollment in mineral economics at Penn State increased substantially in the mid-1960s. Additional faculty were added to the department, and there was a significant increase in the number of graduate students. In 1968, the Colorado School of Mines created a separate department of mineral economics and began offering a master of science degree. The Ph.D. was approved there in 1973 and the first doctorate was granted in 1974.

Richard C. Bradt Receives International Award

Dr. Richard C. Bradt, professor of ceramic science and engineering and head of the Department of Materials Science and Engineering, has been selected as the 1980 U.S. recipient of the Richard M. Fulrath Award.

Dr. Bradt is being recognized for his work on the relationships between the structure and mechanical behavior of ceramic materials.

Inaugurated in 1978, the Fulrath Awards are international with both U.S. and Japanese ceramic scientists being recognized each year. Dual symposia are held in Japan and the U.S. with the awardees serving as speakers. Dr. Bradt will make technical presentations at symposia held in conjunction with an American Ceramic Society meeting in San Francisco in October, and a meeting of the basic science division of the Japanese Ceramic Society in Nagoya in January.

Administered in the U.S. by the Department of Materials Science and Mineral Engineering at the University of California at Berkeley and the Northern California Section of the American Ceramic Society, the Fulrath Awards were established by a joint U.S.-Japanese committee to honor the late Professor Richard M. Fulrath. A member of the faculty of the University of California at Berkeley, Dr. Fulrath made many contributions in both the U.S. and Japan to the study of technical ceramic materials. He died in 1977.

Dr. Bradt is the co-editor of five volumes of proceedings of international symposia in the area of structure and mechanical behavior of ceramic materials. He has published more than 100 research papers with students and colleagues, and has advised or co-advised nearly 50 graduate students in their research.

Last year, he spent a sabbatical in Japan as visiting professor of mechanical engineering at The National Defense Academy, Hashirimizu, Yokusuka.

In the 1970s, the number of graduate departments offering formal programs leading to masters' and Ph.D. degrees in mineral economics continued to increase. West Virginia University offers both masters' and Ph.D. degrees, and the University of Arizona has also established a full-fledged graduate program. It is interesting to note that the faculties of the three schools which have established graduate programs within the last decade have on them either people who received their Ph.D. degrees from Penn State or former Penn State faculty members.

With the emergence of the energy issue and the predictions of doom resulting from mineral exhaustion, such as the Club of Rome warnings of the early 1970s, industry, government, and the research institutions increasingly asked for professionally trained mineral economists.

Enrollment at Penn State began to grow in the mid-1970s until undergraduate majors now number approximately 140. Our graduate program has been maintained in the range of 30 to 40 students by a deliberate decision to hold the numbers to those who can be professionally prepared at current faculty levels.

The newer graduate programs at other institutions are prospering too, with enrollment at the Colorado School of Mines in the range of 90 students, and both Arizona and West Virginia are attracting substantial numbers of students. The degree has been recognized by industry and government, and both undergraduate and graduate students are finding ample employment opportunities at very attractive salaries.

The Penn State Department Today

The Department of Mineral Economics here at Penn State is housed in the Eric A. Walker Building at the western entrance to the campus adjacent to Atherton Street. There are four senior members of the faculty and two faculty positions which are filled at the assistant professor and instructor level. To illustrate the diversity of talent that is attracted to this field and that forms the basis for the professional recognition of mineral economics as a separate field, let us introduce these faculty members.

Professor William A. Vogely, head of the Department since 1975, received his professional training as an economist, earning a Ph.D. from Princeton University. He became interested in mineral economics when he joined the Office of Chief Economist of the Bureau of Mines in 1950. He spent the next 24 years in mineral economics almost entirely with the federal government. He was senior Natural Resource Advisor to the Secretary of the Interior when he joined the Penn State Department of Mineral Economics in July 1974. He was active in establishing the Council of Economics within the AIME and in raising the professional awareness of mineral economics as a separate discipline both in the government and in academia. He has supported and given the aid of the department and the University to the establishment of the sister departments at West Virginia and Arizona.

Professor Richard L. Gordon has been at Penn State since 1964. He holds a Ph.D. in economics from Massachusetts Institute of Technology, and had industrial experience prior to joining the faculty. He has specialized in the energy industries, with his major emphasis being on the worldwide development of coal. He is the author of a number of books on the coal industry both in Europe and the United States, and has undertaken a significant amount of basic and primary research in energy economics and industrial organization of the energy industries.

Professor John E. Tilton joined the department in 1972. His interest is in the economics of the metals industries and he has published widely in this field. He received his doctorate in economics from Yale University and served with the Brookings Institution and the University of Maryland before joining the department.

Associate Professor George Schenck received his Ph.D. in mineral economics from Penn State. Trained as a mining engineer at the Colorado School of Mines, he earned a master's in business administration from Carnegie Mellon prior to entering the graduate program here. His professional interests are the nonmetallic minerals including coal. He has worked extensively in the area of project evaluation and teaches not only mineral economics courses, but also courses in the evaluation of chemical raw materials offered jointly with the Department of Geological Sciences.

Jonathan Fletcher, whose Ph.D. in mineral economics will be awarded by Penn State within a few months, is the newest member of the faculty. Appointed an assistant professor, effective July 1, he holds a bachelor's degree in geology and a master's degree in the geological sciences. His research interest lies in the area of exploration policy and strategy.

The position of instructor is filled on a year-by-year basis by a senior graduate student in the department who wishes to explore the possibility of teaching as a career. Our graduate students are drawn from a wide variety of prior training, most often in mineral engineering or the earth sciences. However, we have graduate students from business administration, economics, and other disciplines.

There is no question that the professional discipline of mineral economics, largely nurtured by The Pennsylvania State University, has now reached maturity. This department and the others in the United States are attracting students from throughout the world. Former Penn State students are now teaching and practicing on every continent and are spreading the discipline on a worldwide basis. We look forward to a continued growth in both the quantity and quality of professional mineral economists throughout the world.

The Author

Dr. William A. Vogely has been head of the Department of Mineral Economics since 1975. Before coming to Penn State in 1974, he served as acting deputy assistant secretary, Department of the Interior. He has held various positions in the U.S. Bureau of Mines, Bureau of Land Management, and Internal Revenue Service. Along with his activities in the government, he also taught at George Washington University. He is the author of many publications in the mineral resource field.

Aid Sought to Replace Microseismic Facility

The mobile microseismic monitoring facility of the Geomechanics Section of the Department of Mineral Engineering was destroyed by fire in January, and financial support from industry is being sought to enable its replacement.

The mobile facility consisted of a cargo-type van equipped with electronic instrumentation for recording microseismic activity generated by instabilities in large geological structures such as coal or limestone mines or underground storage reservoirs for natural gas.

Developed in the early 1970s by Dr. H. R. Hardy, Jr., professor of mining engineering and chairman of the Geomechanics Section, and his associates, the facility had been used extensively on instructional and research projects. Much of the research, which was sponsored by industry and government agencies, was energy-related. Its use in monitoring gas storage reservoirs, as they were filled, to determine optimum safe storage pressures was described in the April 1975 issue of this bulletin.

The facility was being used on a routine microseismic monitoring mission at an underground limestone mine in Maryland when the fire, apparently due to an electrical malfunction, occurred.

Replacement cost of the facility is estimated at $126,000. This spring, Robert L. Frantz, head of the Department of Mineral Engineering, sent a letter to alumni of the department, seeking their help in efforts to obtain industrial or other grants in the range of $10,000 to $20,000 to assist in replacing the facility.

Anyone who can help in any way may write or call Professor Frantz, 104 Mineral Sciences Building, University Park, Pennsylvania 16802; (814) 865-3437.

The first Robert W. Lindsay Award to a student who does outstanding work in course areas formerly taught by Dr. Robert W. Lindsay, professor emeritus of metallurgy, was presented at the annual awards dinner of the College of Earth and Mineral Sciences by Dr. Lindsay, center, to Michael L. Schmidt, who received his B.S. in metallury with high distinction at Penn State's spring commencement. Looking on is Dr. Kenneth E. Pinnow, who introduced Dr. Lindsay, noting that the award was established in his honor by colleagues, friends, and former students. Dr. Pinnow, who received his M.S. and Ph.D. in metallurgy at Penn State, is now manager of process research with Crucible Steel Company, Pittsburgh.

103 Degrees Granted; Thesis Titles Listed

A total of 103 degrees were granted by the College of Earth and Mineral Sciences at the University's fall term commencement last November.

Fifty-seven bachelor of science degrees, ten associate degrees, and thirty-six advanced degrees were awarded.

Following is a list of the thirty-six advanced degree recipients and the titles of the theses or papers they prepared as partial requirements for their degrees. Information on borrowing or purchasing copies of these papers or theses may be obtained from the editor of this bulletin.

Ceramic Science—Michael David Meiser, Ph.D., *Mechanical Behavior of a Low-Density Aluminous Cement-Bonded Composite;* Norihiko Sinkai, Ph.D., *Fracture of PbO-ZnO-B_2O_3 Glasses.*

Earth Sciences—Clifford Edwin Vonarx, M.Ed., *Geology of the Horseshoe Curve—Upper Devonian to Lower Pennsylvania.*

Fuel Science—David S. Liscinsky, M.S., *Evaluation of an Automated Reflectance Microscope System for Coal Characterization.*

Geochemistry & Mineralogy—David Lynn Ozsvath, M.S., *Modelling Heavy Metal Sorption from Subsurface Waters with the n-Power Exchange Function;* Peter Mwakio Tole, M.S., *The Uranium Content of Zircons from the Catskill Formation, Eastern Pennsylvania.*

Geography—Bernard Ikubolajeh Logan, M.S., *Experiments in Multiple Location Analysis: The Eastern Sierra Leone Example;* and *Guyana's Foreign Trade Policy and Implementation: A Radical View;* Ryan Rudnicki, Ph.D., *Peopling Industrial America: Formation of Italian and Polish Settlements in the Manufacturing Heartland of the United States, 1880-1930.*

Geology—Deborah Lynn Delfel, M.S., *Palynostratigraphy and Paleoecology of the La Bentana Formation, Cretaceous-(Maestrichtian) San Juan Basin, New Mexico;* Kenneth William Kuehn, M.S., *An Automated Microscopical Method for the Characterization of Pyrite in Coal;* Randall L. Maud, M.S., *Stratigraphy and Depositional Environments of the Carbonate-Terrigenous Member of the Crystal Spring Formation, Death Valley, California;* David Wayne Oldham, M.S., *Analysis of the Relationships Between Composition and the Occurrence of Bloating Shales and Clays in the Pennsylvanian System of Western Pennsylvania.*

Geophysics—Abraham Biadgelgne, M.S., *Third Derivative Analysis of Gravity Anomalies From Prismatic*

Sources; James L. Dein, Ph.D., *Effect of Transformation on Superplastic Properties within the Olivine-Spinel Transition Zone of the Earth's Mantle;* Sally Ann Griffiths, M.S., *Determination of Depth Extent of Tabular Dikes by Wavenumber-Domain Magnetic Interpretation;* William Edward Resley, M.S., *Ultrasonic Determination of Elastic Properties of the Olivine, (Mg, FE)$_2$SiO$_4$, Solid Solution Series.*

Metallurgy—Bruce Lee Tuttle, Ph.D., *Investigations into the Grain Refinement of Copper.*

Meteorology—Allen Conrad Dittenhoefer, Ph.D., *The Chemical Transformation of Sulfur Dioxide to Sulfate in the Plume of the Coal-Burning Keystone Power Plant;* Alfred F. Ferullo, Jr., M.S., *Stratospheric Transport of Ozone by Planetary Waves and by Mean-Meridional Circulation;* Paul Jeffrey Kocin, M.S., *Remote Estimation of Surface Moisture over a Watershed;* Judith Ann Korrell, M.S., *An Evaluation of a Cooling Tower Vapor Plume Model;* Timothy John Method, M.S., *Pollutant Radiative Heating and Aerosol Visible Band Extinction Characteristics in the St. Louis Mixing Layer during Metromex;* Steve S. Schotz, M.S., *Wind Profile Characteristics at the Boulder Atmospheric Observatory—A Preliminary Investigation;* David Alan Yost, M.S. *Stationary Solutions to Low-order Spectral Models of Horizontally and Vertically Thermally Forced Convection.*

Mineral Engineering Management—Orestes Adalberto Espinoza, M.E., *A Feasibility Assessment of Centromin's Casapalca Mine.*

Mineral Processing—Timothy J. Olson, M.S., *The Response of Coal, Mineral Matter, and Locked Particles in a Coal Flotation System;* Nigel Peter Weymont, Ph.D., *The Analysis and Simulation of Autogenous Grinding Systems.*

Mining Engineering—Kenneth P. Katen, M.S., *Measurement of the Heat Generated by Electrical Currents in Shuttle-car Trailing Cables.*

Petroleum and Natural Gas Engineering—Suleiman Mohammed Shamsaldeen, M.S., *Effect of Flood Advance Rate and Micellar Solution Slug Size on Tertiary Oil Recovery in Oil-Wet and Water-Wet Systems.*

Solid State Science—Dinesh Kumar Agrawal, Ph.D., *Phase-Relationship, Vibrational Spectra and Luminescence Studies in Rare Earth (Y,Gd) – Phosphate Systems;* Ahmed A. Hussein Amin, Ph.D., *Phenomenological and Structural Studies of Lead Zirconate-Lead Titanate Piezoceramics;* Sarah Ann Gallagher, Ph.D., *Cesium Aluminosilicates for Nuclear Materials Applications;* Laurence Ralph Gilbert, Ph.D., *Bulk and Sputtered Thin Film Ba(Pb,Bi)O$_3$): A Ceramic Superconductor;* Jon Francis Hauris, M.S., *A Sensitive Capacitor Dilatometer for Electro-mechanical Strain Measurements;* Sei-Joo Jang, Ph.D., *Electrostrictive Ceramics for Transducer Applications;* Thomas J. Yurick, M.S., *A Thermodynamic Study of the Ti-B-N System.*

College News Notes

1980 Student Awards Presented

One graduate and twelve undergraduate students in the College of Earth and Mineral Sciences received awards at the college's 12th annual awards dinner last spring.

The Robert W. Lindsay Award in metallurgy, described elsewhere in this issue, and the E. Willard Miller Awards in geography were presented for the first time this year.

The Miller Awards honor Dr. E. Willard Miller, associate dean emeritus for resident instruction in the college and professor emeritus of geography, who retired in June after serving 35 years on the faculty. The two awards go to the winners of graduate and undergraduate student paper competitions. This year's undergraduate winner was Melissa M. Wolfe, a senior from Pittsburgh, Pa. The graduate winner was Richard J. Eaton, of State College, Pa.

The 1980 Ellen Steidle Achievement Awards, which recognize outstanding service to the college and its student body, were presented to Clare O'Shea, earth sciences junior from Bethel Park, Pa., and two spring term graduates, Joseph S. Campisi, earth sciences major from Simsbury, Conn., and Barbara J. Wanamaker, geosciences major from King of Prussia, Pa. These awards, established by the late Dr. Edward Steidle, dean of the college from 1928 to 1953, honor the memory of his wife. Miss O'Shea is president of the Earth and Mineral Sciences Student Council while Mr. Campisi is its immediate past president. Miss Wanamaker served as chairman of the college's 1978 open house program.

The William Grundy Haven Memorial Awards are given to the winners of a student technical paper competition. Dale E. Adams, geography sophomore from Sayre, Pa., received first prize for his paper entitled "A Proposal for Public Transportation in Rural Areas." Second prize went to Jay M. Galbraith, metallurgy junior from Harrisburg, Pa., for "The Deformation of Metals at High Temperatures." Third prize winner was Chandra L. Mowery, geosciences junior from Carlisle, Pa., for "Vegetation Responses to Spray Irrigation of Secondary Treated Sewage Effluent and Nutrient Utilization by the Treated Vegetation."

The George W. Brindley Award for Undergraduate Excellence in Crystal Chemistry was presented to Judith A. Nemetz, ceramic science and engineering junior from Whitehall, Pa. John Hall, a senior in meteorology from North Huntingdon, Pa., received the Jerome N. Behrmann Award in meteorology. Ann E. Mera, polymer science junior from Nanticoke, Pa., received the DuPont Award to the Outstanding Junior in Polymer Science. Julianne M. Turko, geosciences junior from Carnegie, Pa., received a special plaque in recognition of her service as chairman of the undergraduate committee that planned the college's 1980 open house program.

Win Meteorology Award

Two recent meteorology graduates have received the 1980 Father James B. Macelwane Award of the American Meteorological Society for having submitted the best paper in the Society's annual student paper contest.

In recognition of Dr. E. Willard Miller's many years of service to students of the College of Earth and Mineral Sciences as associate dean for resident instruction, Clare O'Shea, president of the Earth and Mineral Sciences Student Council, presented him an engraved Nittany Lion statue replica at the college's annual spring awards dinner. Dean Miller retired in June as associate dean emeritus and professor emeritus of geography after serving 35 years on the faculty.

Honored were Gerard Butch, who received his B.S. in May 1979, and Jay Schlegel, who graduated in November 1977. Mr. Butch is now employed by the U.S. Geological Survey in Indianapolis, Ind., and Mr. Schlegel works for Weather Services in Boston.

Their paper, entitled "The Barrens: Central Pennsylvania's Year-round Deep Freeze," was an account of their findings during a year-long monitoring of temperatures in the Barrens, an area of stunted tree growth and little vegetation located about four miles from Penn State's main campus. Although the area has long been known for its temperature extremes, theirs were the first formal efforts to keep continuous records over a considerable length of time.

Frost in midsummer is not uncommon in the Barrens, they found, and the area can produce as many as a month of sub-zero minimum-temperature nights a year while the University campus, just four miles away, normally experiences only one.

An article about their project appeared in the June 1979 issue of this bulletin.

1980 Taylor Lecturer

Dr. Morris Cohen, Intitute Professor Emeritus in the Department of Materials Science and Engineering at the Massachusetts Institute of Technology, will deliver the 1980 Nelson W. Taylor Lectures in Materials Science in September.

Dr. Cohen is world renowned for his work in ferrous-physical metallurgy and has done ex-

E&MS Short Courses

Folders describing the following continuing education offerings of the College of Earth and Mineral Sciences at Penn State's University Park Campus may be obtained by writing (Name of Program), Keller Bldg., University Park, PA 16802; or by phoning 814-865-7557.

Coal Mine Electrical Systems, August 18-21.

Application of Fracture Mechanics to the Failure of Ceramics and Glass, August 18-22.

Materials Transport in Mining, August 25-27.

Workshop on Diesel Equipment in Underground Mines, September 3-5.

Design of Hydrology Aspects of Surface Mines to Achieve Regulation Compliance, September 8-10.

Cement Manufacturing Technology, September 8-11.

Mineral Exploration and Evaluation — Coal, Industrial Minerals, Petroleum, and Natural Gas, September 29-October 3.

Technical Elements of Surface Coal Mining and Land Reclamation, October 1-3.

Lime Manufacturing Technology, October 13-14.

Fundamentals of Rock Mechanics, October 27-29.

Strata Control Engineering, October 29-31.

Elements of Coal Preparation, November 10-12.

Coal Mining Development, November 12-14.

Elements of Underground Coal Mining, November 17-19.

How to Evaluate Innovative Mining Equipment in Underground Coal Mines, November 17-19.

Advanced Short Course on Coal Preparation, December 1-3.

tensive work on martensite, a metastable phase of steel.

He will speak on materials and society at 7 p.m., Monday, September 29, and on some aspects of displacive phase transformations at 4 p.m., Tuesday, September 30. Both lectures will be in 26 Mineral Sciences Building.

The Taylor Lectures, sponsored by Penn State's Department of Materials Science and Engineering, honor the memory of Nelson W. Taylor, professor and head of the then Department of Ceramic Science from 1933 to 1943.

Newnham Speaks in England

Dr. Robert E. Newnham, professor and head of the solid state science program at Penn State, recently served as the keynote speaker at the 17th Annual Solid State Physics Conference sponsored by the Institute of Physics of Great Britain and held at the University of Warwick in Coventry, England.

He spoke on "Ferroic Crystals," describing some of the ferrobielastic, ferroelastoelectric, and magnetoferroelectric materials under investigation at Penn State.

Before returning home, he also gave a seminar at the Atomic Energy Research Establishment at Harwell, England, discussing "Composite Piezoelectric Transducers."

Knight Named Editor

Dr. C. Gregory Knight, professor of geography, was recently appointed editor of the *Resource Papers of the Association of American Geographers.*

He is the first person outside the office of the association to serve as editor. The papers are a monograph series on topics having to do with the undergraduate and continuing education of professional geographers.

Receives AMS Meisinger Award

Dr. Richard A. Anthes, professor of meteorology, has received the Clarence Leroy Meisinger Award of the American Meterological Society.

Presentation of the award was made at the Society's 1980 annual meeting early this year in Los Angeles, California. The award recognizes an individual for research achievement that is, at least in part, aerological in character. Dr. Anthes was honored for research and modeling in tropical cyclones and mesoscale meteorology.

Late last year, he was an invited speaker at an international conference on tropical cyclones held in Perth, Australia, where he discussed computer modeling of such cyclones over the past 15 years.

Voight Edits Rockslide Book

Dr. Barry Voight, professor of geology, is the editor of *Rockslides and Avalanches, Part 2, Engineering Sites,* published recently by Elsevier Scientific Company, New York. He also edited *Rock Slides and Avalanches, Part 1, Natural Phenomena,* published by Elsevier two years ago.

The two volumes are described as bringing together for the first time the full scope of geological and geotechnical studies of the major mass earth movement events of the Western Hemisphere, described in detail and interpreted by recognized experts. The books are expected to become the standard reference works on mass movements.

Major topic areas in the most recent book include slides near canals, lakes, reservoirs, and fjords; slope excavations for transportation routes; and open pit mine slopes.

Dr. Voight is also co-author of four chapters in this book. One of his co-authors is Dr. R. L. Slingerland, assistant professor of geology.

Alumni Urged to Return Directory Questionnaires

Alumni of the College of Earth and Mineral Sciences have each received two questionnaires seeking information for the college's alumni directory to be published late this year.

If you are an alumnus and have not yet returned one of these questionnaires, please do so at once. There is no need to return more than one. If you do not wish your name listed in the directory, you should so indicate on a questionnaire and return it.

Beginning in late summer, personnel of the Bernard C. Harris Company of White Plains, N.Y., which is compiling, printing and marketing the directory, will begin phoning alumni to verify information received or solicit information if it has not been submitted. During this phone call, the alumnus will also be invited to purchase a copy of the directory. Only enough directories to fill prepublication orders will be printed, and circulation will be closely restricted to alumni.

The college will not benefit financially from the sale of the directory, but both the college and tbe University will derive substantial benefit from the comprehensive updating of alumni records that will result from the Harris efforts.

Contributors to Two Books

Several faculty and staff members of the Department of Mineral Engineering are contributors to two books on computer applications in the mineral industries that were published recently by the Society of Mining Engineers of the American Institute of Mining, Metallurgical, and Petroleum Engineers.

Computer Methods for the 80's in the Mineral Industry, edited by Alfred Weiss, president of Mineral Systems, Inc., a Connecticut-based consulting firm, has a foreword by Dr. Robert Stefanko, professor of mining engineering and associate dean for continuing education in the College of Earth and Mineral Sciences, who was 1979-80 president of the Society of Mining Engineers. Dr. R. V. Ramani, professor of mining engineering, served on the book's editorial advisory board.

Faculty and staff who are authors or co-authors of chapters in this book are: Dr. Ramani; C. B. Manula, also professor of mining engineering; Dr. J. M. Mutmansky, associate professor of mining engineering; L. B. Phelps, instructor in mining engineering; Frank Camilli, graduate assistant; and Judith Kiusalaas, research aide.

The second book is *Application of Computers and Operations Research in the Mineral Industry,* the proceedings of the 16th international symposium on this topic held last fall at Tucson, Arizona. Thomas J. O'Neil, of the University of Arizona, served as chairman of the symposium and editor of the book. Three Penn State faculty members served as session chairmen for the symposium—Dr. Ramani, Professor Manula, and Dr. J. C. Griffiths, professor emeritus of petrography.

Among the authors and co-authors of chapters in the book are Dr. Ramani, Professor Manula, and two graduate assistants, E. K. Albert and S. Bandopadhyay.

Bulletin to Begin 50th Year of Publication

The September/October issue of this bulletin will be the first one in its 50th year of publication. This milestone is being reached in Penn State's 125th anniversary year.

For the final year of its first half century, the bulletin will feature a series of special issues, each devoted to a specific area.

The September/October issue will review the growth and development of the College of Earth and Mineral Sciences during the last 50 years, looking at where it has been, where it is, and where it plans to go. Special articles will also review the history of the bulletin and of the Earth and Mineral Sciences Museum.

The November/December issue will review Penn State's radioactive waste management research in four articles written by faculty members engaged in this work. The January/February 1981 issue will feature the Department of Mineral Engineering; the March/April issue, the Department of Meteorology; the May/June issue, the Department of Geosciences; and the July/August issue, the Department of Materials Science and Engineering.

Heads Exploration Geochemists

Dr. Arthur W. Rose, professor of geochemistry, assumed the presidency of the Association of Exploration Geochemists at the organization's biennial international symposium held last spring in Hannover, West Germany. The association has members from about 50 countries.

At the symposium, Dr. Rose presented a paper, "Regional and Local Uranium Anomalies in the Devonian Catskill Formation near Sandstone-type Uranium Prospects in Pennsylvania," which was co-authored by him and Simon Pirc, Peter M. Tole, and Christy Bell, current and former geochemistry graduate students.

Serves on Coal Commission

Jess F. Core, adjunct professor of mining engineering, retired U. S. Steel vice president, and 1937 mining engineering graduate who was named a Distinguished Alumnus of Penn State in 1966, served as a member of the President's Commission on Coal which was appointed by President Carter in the spring of 1978 to study the U.S. coal situation.

John D. Rockefeller IV, governor of West Virginia, served as the commission's chairman. Other members were Marvin Friedman, a Washington, D.C., lawyer; W. Dewey Presley, director and chairman of the executive committee of First International Bancshares, Dallas, Texas; and Willard Wirtz, former Secretary of Labor. Charles W. Duncan, Jr., Secretray of Energy; Ray Marshall, Secretary of Labor; three senators; and three representatives were ex officio members.

In its report, issued last March, the commis-

Looking, Listening, Learning—Visitors of All Ages Attend 1980 College Open House

An estimated 3,500 people saw more than 60 exhibits, demonstrations, and films in the disciplines covered in the College during the two-day 1980 Earth and Man Exposition.

Above left, Dr. Deane K. Smith, professor of geochemistry, works on gemstones in the lapidary laboratory while visitors view specimens through microscope and magnifying glass. Above right, metallurgy students pour molten aluminum into a mold while visitors watch. Their exhibits were judged the most popular of the open house. Left, Bill Varnell, polymer science graduate student, demonstrates "melt spinning" of strands of polymer fiber. Below left, petroleum and natural gas engineering students set up this spring-pole drilling rig in front of Mineral Sciences Building and invited visitors to help them demonstrate how early water and oil wells were drilled. Below center, Jim Hollian, meteorology freshman, explains a display in the acid rain laboratory. Below right, a youngster makes a rock "talk" in a rock mechanics laboratory display while Dr. W. A. Khair, research assistant, explains the apparatus to her mother. (Those are balloon strings tied to the small girl's wrist.)

sion reported that it had concluded that the problems associated with coal use can be overcome and that the nation must begin to rely more heavily on its vast coal deposits to reduce dependence on imported oil.

Coal, it said, must replace oil and natural gas now used in generating electricity and in large industrial boilers. Natural gas must be directed toward replacing oil in home and commercial heating and in industrial uses where coal is impractical. Oil must be directed primarily toward petrochemical products and transportation uses.

Recent Faculty Talks and Travels

Dr. Guy E. Rindone, professor of ceramic science and engineering, late last year, spoke on materials processing in space to the New Mexico Section of the American Ceramic Society in Santa Fe, and to Los Alamos Laboratory staff members; and gave a seminar on his research on glass microstructure and properties as influenced by the melting atmosphere at the Sandia Laboratories in Albuquerque, N.J.

Dr. James J. Reuther, assistant professor of fuel science, recently presented two lectures, "Coal Characteristics and How They Relate to Combustor Design" and "Combustion-Generated Air Pollution," at an applied combustion technology course given by the Center for Professional Advancement of East Brunswick, N.J. The course was attended by about 60 engineers and scientists from various industries.

Dr. Anthony V. Williams, associate professor of geography, and Nancy Murdock, geography graduate student, presented a paper, "Energy and the Census," at the annual meeting of the Association of American Geographers in Louisville, Kentucky, last spring. The paper reported on the authors' examination of the quality and reliability of energy-related data in the population and housing census. Using 1970 census data and focusing on Philadelphia, they concluded that some concern is warranted about the accuracy of 1980 data.

Dr. John C. Griffiths, professor emeritus of petrography, gave an invited seminar on "Problem Solving in Geosciences" to faculty and students of the Department of Geology at Kent State University last spring.