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A Digital Terrain Modeling Package

This mini-atlas highlights a new cartographic tool available for mapping landforms and analyzing surface processes

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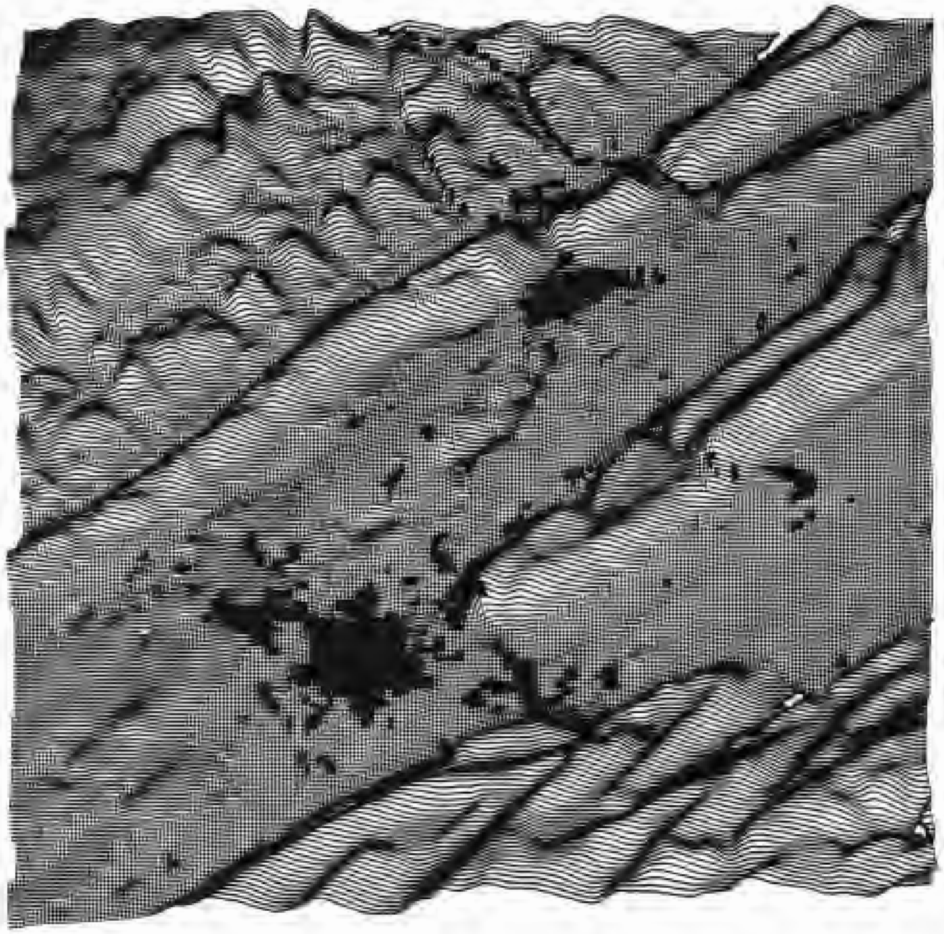

Figure 1. Perspective plot of State College area from 1:250,000 DEM. Urban development and major transportation are shown as a black overlay.

The traditional view of a cartographer is that of an individual bent over a drafting table inking a map. Today's cartographer is more likely to be found peering at a video display terminal and involved in activities far more technical than map compilation and drafting.

Revolutionary methods of data acquisition by aircraft and satellite, and the development of computer technology to display this information have changed the manner in which maps are prepared and used. This article gives a brief look at one aspect of this new cartography in the form of a mini-atlas of digital terrain models centered on the State College area of central Pennsylvania.

Digital terrain models (DTM) are derived from digital elevation models (DEM) which are currently being produced by the U.S. Geological Survey's Orthophoto Mapping Program. Each DEM consists of a gridded data set of elevations (Universal Transverse Mercator projection) with a ground spacing of 30 meters, and covering a 1:24000, 7.5-minute topographic map. The data set of elevations used to produce the State College images in this atlas contains 452 rows with 333 grid cells per row, for a total of 150,516 elevation values.

The DTMs were generated from a library of programs developed by the author and refered to as the Digital Terrain Modeling Package (DTMP). The computer programs will be available as part of a monograph to be published in the Resource Publication series of the Association of American Geographers. The series editor is C. Gregory Knight, professor and head of Penn State's Department of Geography.

The Digital Terrain Models generated by the package are listed in the Table and examples of some of the models are shown in graphic form in the following pages.

The type of display used for the majority of the figures is a form of image processing called gray scale or brightness mapping. High values are represented as white tones, low values are represented as black tones, and intermediate values are shown as different shades of gray. This type of presentation allows for the maximum amount of detail to be presented to the viewer. Other graphic displays, such as contour maps, perspective plots, and classed maps can also be created by the DTMP. These digital terrain models not only provide the basis for creating a graphic depiction of the earth's landforms; they also provide the data for modeling the earth's surface processes, such as runoff and erosion.

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The Digital Terrain Modeling Package

Figure	DTM	Description	Derivation
3	slope magnitude	maximum rate of change of elevation	vector magnitude obtained from directional first derivatives of elevation
—	slope direction	azimuth of maximum downslope	vector azimuth from directional first derivatives of elevation
4	edge magnitude	maximum rate of change of slope	vector magnitude from directional second derivatives of elevation
—	edge direction	azimuth of maximum rate of change of slope	vector azimuth from directional second derivatives of elevation
—	LaPlacian edges	signed (flat, concave, convex) maximum rate of change of slope	isotropic second derivative of elevation (not scaled)
5	downslope curvature	true curvature values (flat, concave, convex) for the DEM in the direction of maximum downslope	directional second derivative of elevation (scaled)
—	across slope curvature	true curvature values (flat, concave, convex) for the DEM in the direction crossing the maximum downslope	directional second derivative of elevation (scaled)
6	flow path	path followed by water falling on DEM	steepest descent algorithm. magnitude of flow is accumulated at each grid cell location
—	path length	length of flow path	steepest descent algorithm. route lengths are calculated for each grid cell with flow traced back to a divide
7	Lambertian surface	normalized lighting values for a landform surface, assuming equal coefficients of scattering	cosine function of solar position landform geometry (slope magnitude and aspect)

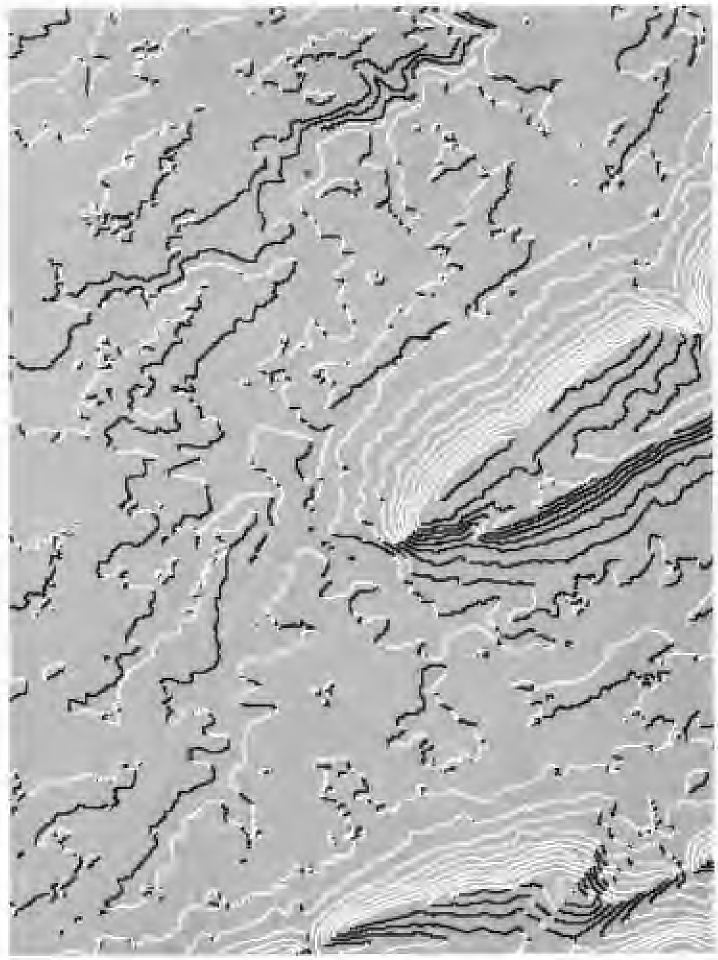

Figure 2. Right, above: Illuminated contour plot of State College 1:24,000, 7.5-minute DEM.

Figure 3. Right: Gray scale or brightness map of slopes for the State College DEM. Steep slopes (white) can be seen on the sides of Mt. Nittany and the channel walls of Spring Creek.

Figure 4. Gray scale map of edges showing rapid breaks in slope as white. The incomplete State College bypass can be traced as a set of edges.

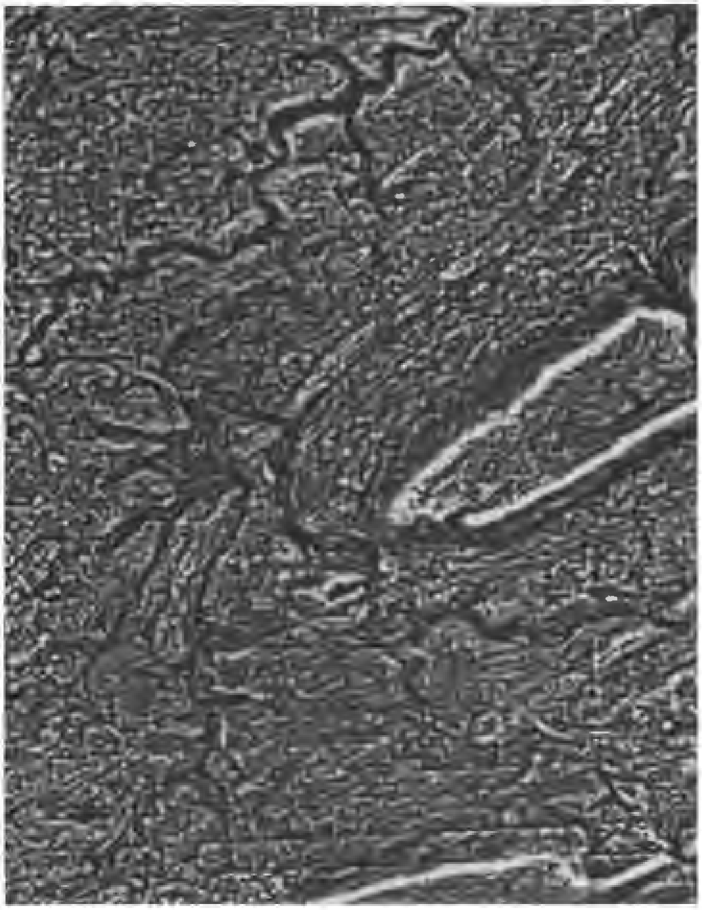

Figure 5. Down slope curvatures show concave (black) and convex (white) landform elements.

Figure 6. Classed flow map showing high frequency of flow (white), medium frequency of flow (gray), and no flow areas or divide (black).

Figure 7. Hill shaded map from a Lambertian surface generated with northwest solar lighting at an inclination of 30 degrees.

Coal-Water Slurry Fuels

A Fuel Technology
Poised for Commercialization?

ROBERT G. JENKINS, Chairman, Fuel Science Program

Two important research and development thrusts that have emerged in the last decade and a half have been the search for alternatives to petroleum-based fuels and natural gas, and the obvious need to find ways of expanding the use of our vast indigenous coal resources. Among the many schemes proposed to achieve these goals, one of the most interesting has been the development of coal-water slurry fuels.

Coal-water fuel (CWF), a liquid fuel made from pulverized coal, has come into prominence as the result of a widespread international research and development effort that encompasses research groups, companies and agencies in the United States, France, Germany, Italy, Canada, Japan, the Peoples Republic of China, Sweden, the United Kingdom, and the Philippines.

Perhaps the most important factor that has motivated this research is that CWFs are projected to cost approximately two-thirds the cost of a heavy fuel oil on a caloric basis. Since coal-water fuels allow coal to be handled as a liquid, they can be pumped and stored as an oil substitute. After some modifications have been made to the combustor, there is the potential for firing a CWF directly into a previously oil-fired furnace or boiler. Thus, CWFs offer an alternative to oil firing. Compared to other developing technologies such as indirect or direct coal liquefaction, which produce substitute petroleum products, or coal gasification to make methane, it presents a relatively simple and cheap technology that can provide us with a degree of insurance against the uncertain future of oil supplies. As will be seen later, it is a technology in which the College of Earth and Mineral Sciences is playing a significant role.

What is Coal-Water Fuel?

In a generic sense, CWFs are simply combustible mixtures of coal and water in a pumpable slurry form. During development it has been found that these fuels can be used, with varying degrees of success, in applications as diverse as utility and industrial boilers, fluidized bed combustors, cyclone burners, blast furnaces, coal gasifiers, diesel engines, and gas turbines (though the last two uses are still very much in the research domain). The coals that have been used to produce CWFs cover the entire range of coal rank from lignites through anthracties, though CWFs based on high-volatile bituminous coals have been investigated most thoroughly. This article focuses on CWFs made from high-volatile bituminous coals that can be used as feedstock for electric power and steam production via 'conventional' utility and industrial boilers.

It is important to recognize that a coal-water fuel should contain as much coal as possible while still remaining a stable pumpable liquid. This maximizes the amount of energy per unit volume (or mass) of the mixture, and should lead to self-sustaining combustion of the CWF. In other words, to burn a CWF successfully in a commercial sense, there should be the minimum input of energy from such other sources as pilot burners, supplemental fuels, secondary air preheat, or oxygen enrichment.

CWFs based on bituminous coals are composed, by weight, of 65 to 75 percent coal, 0.5 to 1 percent additives, and a balance of water. The most commonly quoted formulation is 70 percent coal, less than 1 percent additives, and about 29 percent water. This mixture, for a high-volatile 'A' bituminous coal, would have a heating value of between 9000 and 10,000 Btu/lb, which can be compared with about 18,000 Btu/lb for No. 6 fuel oil, and about 19,400 Btu/lb for No. 2 fuel oil. Obviously, the precise heating value is directly related to the heating value of the original coal and the formulation. The major reduction in heating value between the coal and the CWF is caused by the diluent effect of the water. But it is interesting to realize that the actual energy penalty for evaporating the water in the CWF is only about 3 percent of the total energy released.[1]

Of course, the questions are always asked, "What are the additives?" and "What are their roles?" The specific additives used by the major producers are usually proprietary information—however it is known that they are complex mixtures of organic dispersants and stabilizers which are used to disperse the coal particles in the water to maintain stability.[2] It is very important that a CWF is stable and remains a well-dispersed mixture under the range of conditions encountered in handling and storage. Needless to say, it would not be desirable to have coal particles precipitating into a mass whilst being stored in tanks or transported for delivery.

The additives are also used to modify the viscosity behavior. It is well accepted that the rheological properties of a coal-water fuel are complex—they all exhibit some form of non-Newtonian behavior[3,4,5] which of course will influence the pumpability and the atomization in the combustor.

There has been considerable discussion about the optimum coal particle-size distribution.[5] Two groups of CWFs are recognized: the micronized slurries in which the coal particles are mostly less than 45 μm in diameter; and the 'conventional' CWFs which have a relatively broad particle size distribution and are somewhat similar to conventional pulverized fuels (80 percent less than 74 μm). A final note about mixtures—the coal loading for coal-water fuel is quite different from that commonly reported for the so-called pipeline slurries. In the pipeline slurries used for long distance transportation of coal, the coal loading is usually between 45 and 50 percent, much less than for CWF. To use a long-distance pipeline slurry as a CWF it would be necessary to remove an appreciable amount of water. However, there has been some research into the possibility of using CWFs as pipeline fuels.

Burning the Coal-Water Fuel

CWFs can be burned effectively. This has been well demonstrated and documented on both a fundamental and an engineering scale. It has been found that successful firing usually involves some input of a small quantity of supplementary energy, either in the form of preheating the secondary combustion air (to say 200 to 450°F), or as a supplementary fuel such as a methane pilot flame. Another alternative being tested is the use of modestly oxygen-enriched air as the atomizing gas and/or the oxidant gas.

When a high-volatile bituminous coal slurry is burned, what are the emissions? First, the same amount of ash will be formed as would be produced from burning the same amount of coal. However, the ratio of fly ash to the ash which remains in the combustor might change. The conductivity of the fly ash particles might also be somewhat different—in which case the effectiveness of installed electrostatic precipitators used to reduce particle emissions might be changed and require modification.

The specific behavior of the ash in terms of sticking to the internal parts of furnaces or boilers will probably be somewhat different from the behavior when coal is burned without water. Also, the behavior of the inorganic mineral constituents, and subsequently the coal ash components, will have a significant influence on the application of CWF technology in a given type of combustor—this point will be discussed in greater detail later.

The volume of water vapor emitted when burning a bituminous CWF will be almost the same as that produced from the regular combustion of No. 6 fuel oil. Intuitively, this fact seems a little surprising, but it is the result of the relatively high hydrogen content of the petroleum-based fuel which forms water vapor on combustion.

The total quantity of sulfur (mainly as SO_2 and to a lesser extent as SO_3) that is emitted from a CWF combustor will be the same as the parent coal. However, the amount of polluting nitrogen oxides (so-called NO_x) produced is somewhat reduced compared with emissions from the coal alone, because of the reduced temperatures in the CWF flame.

Combustor Conversion

It must be recognized that conversion to CWF from a fuel oil is not merely a simple matter of changing the oil burner or adjusting the atomizing pressure. There are significant changes which must be made to accommodate the fact that coals, and therefore CWFs, contain relatively large quantities of ash-forming inorganic species.

The quantity of ash-forming species will depend on the inherent inorganic content of the parent coal (which may vary from 5 to 20 percent by weight) and the extent of coal beneficiation used in preparing the slurry. Beneficiation can be applied to the coal just after mining, or carried out during preparation of the fuel. It is possible to prepare CWFs that have very small quantities of inorganic species (less than 1 percent) but this so-called deep cleaning adds significantly to the cost of the fuel. As a result, it is unlikely that the deep cleaning methods would be used in conventional applications. However, these CWFs may well be beneficiated to reduce the inorganic sulfur (mainly FeS_2) in order to lower sulfur oxides emissions. On the other hand, CWFs developed for diesel engines or gas turbines would have to contain the absolute minimum of ash-forming species to prevent excessive wear to moving engine parts, and would therefore require deep cleaning.

At this point the differences between firing CWFs into furnaces or boilers designed for burning pulverized coal and those designed for using fuel oil should be emphasized. A unit designed for pulverized coal combustion already contains facilities to handle the ash which accumulates in the combustor, and the ash which is carried in the flue gas stream—the fly ash. It is also designed to cope with ash that accumulates on the heat exchange surfaces as ash deposits. As a result, the conversion of a coal-fired combustor to handle CWFs will be relatively simple. Some modification will be needed to deal with the lower heating capacity of the new fuel and with possible differences in ash properties.

The situation is very different for a boiler designed to run on fuel oil. The content of ash-forming species in commercial available fuel oils is almost trivial—a No. 6 fuel oil, for example, will have an ash content of less than 0.1 percent. There is essentially no need to incorporate any ash handling systems in these boilers. Heat transfer to the water can be optimized by placing heat transfer tubes quite close together. However, if a conventional CWF is burned in this type of boiler, the spaces between the tubes will become clogged with ash, and because there are no ash handling facilities, ash will also accumulate on the floor of the unit. This type of boiler requires structural modifications to overcome or compensate for the ash problems, and these costs must be offset by the cheaper CWF fuel.

A boiler designed to run on fuel oil has a smaller combustion space than the equivalent unit designed for coal. Although it is claimed that CWF flames burn more compactly than those from pulverized coal, there is still a need to 'derate' the boiler because somewhat less energy is produced from CWF than from fuel oil for that given unit. This must of course be considered in the overall economics of the system.

A last concern related to the inorganic content of the CWFs is the potential life of the atomizer nozzles, since experience has shown that CWFs can be quite abrasive. The lifetime of the burner nozzles has not been particularly long in experimental tests, but there are ways to counteract this effect, such as by using tungsten carbide or hardened metals in appropriate locations in the burner.[5]

What is the Future for these Fuels?

The question still remains, "What is the future of conventional CWF technology in the United States?" CWF technology does provide a viable, relatively cheap alternative to oil. It would allow us to make better and expanded use of our coal reserves. Even with some of the technological challenges not yet completely solved, the basic technology is in place and its effective application has been demonstrated.

CWFs have not yet swept the market place. It is a technology poised for commercialization. What can be done to make its potential a reality? To get the technology off the ground, utility

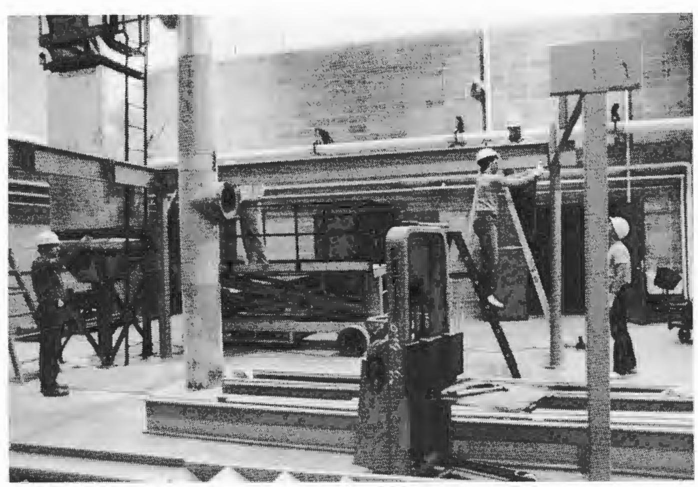

Figure 1. Installing the support structure for the research boiler in the new Combustion Laboratory.

and commercial boiler users must be convinced that coal-water fuels do indeed provide an attractive alternative to fuel oil. They must have a reasonable assurance that the economics of modification, installation, and utilization are a sound proposition. They also need a significant degree of confidence in the supply of CWFs in terms of both delivery and quality. When running on No. 6 fuel oil, for example, a boiler operator knows exactly what is being supplied, because the variations in a given fuel oil are relatively small. This is the type of reliability for CWF that has to be shown to the market.

The only reasonable way to achieve consumer acceptance of coal-water fuels is through full-scale demonstrations that show the operating characteristics of various CWFs over long periods of time. Only then will consumer confidence reach the levels needed in the market place. At that stage the technology will no longer be poised—it will evolve naturally. The problem is, of course, that in an era of apparently stable or reduced fuel oil costs the economics of operation are less of a driving force. This caution and inertia of the market is less a reflection of the technology than evidence of a lack of confidence in our ability to predict future energy prices.

The need for demonstrations operating for long periods is widely acknowledged. But we must now look a little more carefully at the scale of the boiler demonstrations. On the large scale, we have the utility boilers. There is a need, for example, to operate at least one large utility on CWF for a year or more, so that CWF producers can reach a sufficient level of production and sales to evaluate their production costs realistically. The demonstration would need to be structured so that the utility would be guaranteed delivery of a relatively cheap fuel.

Aside from the utility boilers, there are vast numbers of industrial-size boilers and furnaces that could use CWF. There has been much discussion about conversion and demonstration at this scale because of the potential size of the market, and a number of industrial-size CWF projects are in the planning stages. Several boiler conversions are in progress in different parts of the world. However, there has been no known industrial boiler operating full-time on CWF for an extended period of time in the United States — or anywhere else for that matter.

We hope to remedy that deficiency here at Penn State in the near future. We have an exciting new project under way that we feel will be a major contribution to the field. Penn State is to be the site for a demonstration of coal-water fuels in an industrial boiler, using Pennsylvania coals. The project is sponsored entirely by the Commonwealth of Pennsylvania. The successful demonstration of CWF will be of direct help to our ailing coal industry and provide much needed operating experience for the boiler industry.

The Penn State CWF Project

The main goals of the project are to evaluate and demonstrate the feasibility of modifying an industrial-size boiler originally designed for oil firing; operate it with coal-water slurries derived from Pennsylvania coals; and evaluate the effects of long-term CWF firing on boiler performance.

In addition to this demonstration, there is an important research component to be carried out in our combustion laboratories, aimed at giving a better understanding of the chemical and physical phenomena involved in CWF combustion. This research will help us to predict the industrial behavior of CWFs, identify potential problems, and suggest solutions for their optimum use.

The project was initiated early in 1983 when a group of Pennsylvania state legislators proposed that a coal-water fuel demonstration should be housed at Penn State. A year later, an appropriation of $804,000 was made to purchase, install, and modify an oil-fired boiler. An additional $500,000 for fiscal 1984/85 was added to the University's state appropriation to run the project and perform research in the area of CWFs. The then director of Fuel Science's combustion laboratory, Dr. James J. Reuther, was initially in charge of the project. Subsequently, I was asked to coordinate the project, set up a team of faculty from the College, and see the project through to completion.

Figure 2. The research boiler is unloaded prior to installation in the Combustion Laboratory in Penn State's Academic Activities Building, seen in the rear.

Initially, a considerable effort was made to find the best size range for a boiler, and we consulted with many companies and organizations already deeply involved in the CWF area. These discussions revealed a gap in the demonstration of CWF technology at the packaged industrial-size boiler range. That is, at the size range of the majority of industrial boilers in the Commonwealth, this technology is not being tested extensively. We then made an evaluation of the minimum size needed for a reasonable economic evaluation and technological demonstration.

The outcome of the review suggested that the minimum boiler size that could adequately represent this industrially important range was a unit that can generate 25,000 lbs steam per hour (burning 1 to 2 tons of CWF/hour). At that size level we can show industrial feasibility and also minimize both capital and operating costs and materials handling problems. However, it will be sufficiently large that industrial-sized burners can be evaluated.

Once capital cost funds are released, we will move ahead with acquisition of the demonstration boiler, which will be housed in an extension to the East Campus Heating Plant. We will add a bag-house unit to ensure acceptable emission levels.

For the research phase, we have acquired a custom-built research-size combustor/boiler that will allow us to screen a large number of different coal-water fuels produced from a range of Pennsylvania coals. This small unit, rated at about 1000 lbs steam per hour (burning 100 to 200 lbs CWF/hour) was purchased from Cleaver-Brooks. It is an industrial oil-fired boiler that has been modified so that the combustion zone can be probed directly and the coal ash can be collected at various locations for further analysis. A bag filter has been placed between the boiler and the exhaust stack to reduce emissions and to facilitate fly ash capture for research purposes. The research boiler and its bag filter have been installed in our new Combustion Laboratory, which is located in the recently constructed Academic Activities Building. Small quantities of CWFs have already been burned in an experimental test rig to gain experience in handling these liquids and to test analytical procedures. In addition, the test rig and the Cleaver-Brooks combustor/boiler will be used for fundamental studies of the combustion characteristics of CWFs.

Project Personnel

The Coal Water Fuels team includes:
Dr. Robert G. Jenkins, chairman of fuel science, project coordinator
Dr. Len Austin, professor of mineral processing
Dr. Peter Luckie, head of mineral processing
Dr. Alan Scaroni, assistant professor of fuel science
Dr. William Spackman, director of the Coal Research Section
William Kinneman, project associate

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ROBERT G. JENKINS received his Ph.D. in Fuel Science at Leeds University (U.K.) and carried out post-doctoral work at Penn State, 1970-73. He was a senior researcher in the Department of Chemistry of Imperial College of Science and Technology, London, before returning to Penn State in 1975 as a senior research associate in the Department of Materials Science and Engineering. He joined the teaching faculty in 1978, and was named chairman of the Fuel Science Program in 1983.

Coal Mine Respirable Dust

Characterization of coal mine dust is part of a wide-ranged project to combat respirable disease in mine workers

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One of the most serious long-term health problems associated with underground mining is Coal Workers' Pneumoconiosis (CWP), more commonly known as Black Lung Disease. It occurs in some coal workers, normally after 15 or more years of exposure to coal mine dust, and leads to a variety of respiratory problems. Two types of pneumoconiosis are recognized—simple CWP, which has been estimated to affect 6.9 percent of miners and is a condition that does not impair the miner's ability to work nor reduce life expectancy; and a more severe form of black lung (called progressive massive fibrosis) that occurs in about one percent of the cases and results in severe lung damage.[1]

Although the relationship between coal dust and CWP has long been recognized, detailed knowledge of the relationship is insufficient for setting up authoritative guidelines to reduce the health risks for those employed in dusty underground environments. CWP is not only a health problem for workers that causes considerable distress, it is also a very expensive problem—the total annual costs associated with CWP approach two billion dollars.

As part of its efforts to combat CWP, the U.S. Bureau of Mines in 1983 established a Generic Mineral Technology Center to carry out basic research into all aspects of respirable coal dust:
— control of dust generation
— the behavior of dust in the mine
— characterization of dust particles
— interaction of dust and lung
— the relationships among dust generation and mobility and the mine environment, geology, and seam characteristics.

Penn State, West Virginia University, the University of Minnesota, and the Massachusetts Institute of Technology are involved in this research, which is administered from the Department of Mineral Engineering at Penn State.

Our work is one of the seven projects to be conducted at Penn State. We are concerned particularly with the characterization of dust and its relationships with the mine environment, and our main goal is to establish standard procedures for describing and measuring these variables.

Coal Dust

Coal dust is a very complex material that varies greatly in chemical and mineralogical properties. Moreover, it is not the only constituent of respirable dust in the mine. When a coal seam is mined, it is inevitable that rock particles other than coal are included in the material. This rock comes from the mine roof, the floor, and the partings and inclusions within the coal seams. Since the roof and floor strata, the partings and inclusions are often stronger than the coal, mining them frequently causes more dust than mining the coal itself. One of the objectives of our research is to find the relationships between a specific coal's characteristics before it is mined and the respirable dust characteristics after it is mined. We are particularly interested in the size distribution of particles, the chemical properties, and the mineralogical properties.

Many studies have been made of the variables associated with CWP in West Germany, Great Britain and the United States, where engineers, scientists and medical personnel have tried to relate the incidence of CWP to the coal characteristics. They have measured the quantity of free silica in the coal, its ash content, its rank (a classification based on the coal's fixed carbon and calorific content), the mass of respirable dust in the mine atmosphere, and the trace elements found in the coal and the lungs of miners.

For many years, researchers have known that metal miners subjected to respirable dust that is high in free silica have a higher incidence of silicosis than those exposed to dust low in free silica. However, in coal mines the relationship between CWP and free silica is not clear. Studies made by Leiteritz and his associates[2] indicate that greater changes in lung tissue occurred in cases where the respirable dust was high in silica, but other work by Jacobsen[3] and by Naeye[4] and their co-workers indicates that the silica content of coal does not have any clear effect on CWP incidence. In fact, some researchers believe that free silica has little effect unless it constitutes more than 10 percent of the coal seam. Little is known about the effect of other mineral constituents.

A clear relationship between the rank of coal and the incidence of CWP has been demonstrated by Hart and Aslett[5] in Britain, by Reisner and Robock[6] in West Germany, and in the United States by Thakur[7] and Morgan[8], but others believe that the causal factor may be some variable correlated with the rank of coal rather than the rank itself.

In recent years, the relationship between the mass of the respirable dust in the work environment and the prevalence of CWP has been studied extensively, again with mixed results. Jacobsen et al.[9] and Reisner and Robock[6] report strong statistical evidence of the effects of dust mass on CWP incidence; but Morgan et al.[10] report a less concrete conclusion. Nonetheless, the overwhelming nature of the evidence points to the mass of the respirable dust in the working place as one of the CWP causal variables.

The possibility that trace elements in the coal contribution to CWP has so far been investigated in only a few studies. However, research by Sweet et al.[11] in West Virginia and by Sorensen et al.[12] in Pennsylvania and Utah indicates that certain trace elements could possibly influence the development of the disease.

Thus, the previous research has provided some insights into the possible causes of CWP but many additional questions have been raised concerning the actual causal factors. These are the questions we will attempt to answer in our work for the Generic Center on Respirable Dust.

Penn State Studies

The Penn State investigations are being carried out in the field, in the laboratory, and through statistical analyses. The statistical work is based on samples of Pennsylvania coal from the Penn State Coal Sample Bank.

A total of 97 coals have been analyzed for ten trace elements (Ba, Be, Cr, Cu, Ni, Rb, Sr, V, Zn, and Zr). Initially, the 97 samples were grouped by rank into the three major coalfields (the anthracite coalfield of northeastern Pennsylvania, the medium-volatile and low-volatile bituminous coalfield of central Pennsylvania, and the high-volatile bituminous coalfield of western Pennsylvania). The ten trace elements were then analyzed using discriminant and factor analysis techniques to see if any of the trace elements indicated a relationship with CWP incidence.

The results of this study[13] indicate that both chromium and zirconium have a positive correlation with rank, while strontium has a negative correlation. These trends were consistent throughout each of the coalfields, which suggests a possible causal relationship with the incidence of CWP. The interesting aspect of this research is the fact that CWP is also positively correlated with the rank of coal in these Pennsylvania coalfields.

The Dust Laboratory

A respirable dust laboratory has been established in the Department of Mineral Engineering and equipped with an Elpram Systems Inc. aerosol test chamber, shown in Figure 1. This equipment will be used to calibrate dust sampling equipment, establish standard sampling strategies, and test the experimental field procedures. In the photo, the chamber is being used to establish optimal sampling times for an eight-stage aerosol impactor, a dust collecting device that also determines the particle size distribution.

With the possibility that CWP is related to both the coal rank and the mass concentration of respirable dust, a project has been initiated to find out if the standard Hardgrove Grindability Index (HGI) can be used to predict the amount of respirable dust a coal seam might generate. Because the Hardgrove Index can be readily determined for any coal, the relationship between HGI and dust generation is of great practical value.

To test this idea, the standard procedure used to determine the HGI of a coal was first modified to deal with dust in the respirable size range, Figure 2. The PSU Coal Sample Bank supplied 25 coal samples representing each of Pennsylvania's three major coal regions and the HGI value of each coal was statistically related to the coal seam's apparent dustiness.

A linear regression equation indicated that the highest ranked coals produced the least amount of dust. This result conflicts with the findings of others and may indicate that some external variable is producing this effect.[14] Indeed, the mining process may be a candidate for explaining this apparent contradiction with past research.

Numerous references have been made in the literature to the higher incidence of CWP in the anthracite coalfields of Pennsylvania and in the low-volatile bituminous coalfields of southern West Virginia. Because these coals are high in rank, a correlation between rank and the incidence of CWP appears to be evident. However, the underground mining of anthracite often requires mine development in hard rock sediments, and the extraction of the thin low-volatile seams of southern West Virginia often requires the mining of a great deal of the roof and bottom rock to provide adequate clearance for men and machinery. Perhaps this noncoal material represents the contributing factor to the problem. In both cases, the noncoal material is often high in free silica.

This question is still under investigation. Because it is also generally believed that high mass concentrations of dust contribute to the incidence of CWP, in all our field studies we will make every attempt to analyze both the mass concentration of

Figure 1. Graduate student C. Lee demonstrates the capabilities of the dust chamber in the Respirable Dust Laboratory.

respirable dust and the amount of noncoal material mined in order to answer this question.

Future Research

We are now moving into the coal mines with some of this work. Most of the effort is concentrated on studying the relationship of the properties of the coal and geologic materials and the properties of the respirable dust that is generated when the coal is mined. We hope to collect channel and respirable dust samples in a variety of mines in Pennsylvania to provide data for laboratory and statistical analysis. Eventually we will extend this work into neighboring states.

Meanwhile, other researchers in mineral processing are working on the mineralogical and morphological characteristics of the respirable dust. These analyses coupled with those of the researchers at the other universities, who are concentrating on engineering and medical aspects of respirable dust, should give us a firm basis for understanding this problem in underground mines, and hopefully point the way for reducing the incidence of pneumoconiosis in mine workers.

Penn State Respirable Dust Projects

Establishment of Standard Procedures for Characterization of Respirable Coal Mine Dust Potential.
Principal Investigators: J.M. Mutmansky, C.J. Bise, and R.L. Frantz.

A Fracture Mechanics Study of Crack-Propagation Mechanism in Coal, Utilizing Fracture Toughness and Fracture Velocity Concepts.
Principal Investigator: Z.T. Bieniawski.

Prediction of Ambient Dust Concentrations in Mine Atmospheres.
Principal Investigator: R.V. Ramani.

Computer Modeling of Longwall Face Ventilation.
(to begin October 1985)
Principal Investigator: R.V. Ramani.

Characterization of Dust Particles.
Principal Investigators: R. Hogg, P.T. Luckie.

Figure 2. Graduate student Michael P. Moore working with the Hardgrove apparatus in the Mineral Processing Lab.

Wetting Characteristics of Dust Particles in Relation to Dust Abatement.
Principal Investigators: S. Chander, F. Aplan.

Analysis of Coal Particles on a One-by-One Basis, Using an Automated Computer-Controlled SEM with X-Ray Fluorescence.
Principal Investigator: L. Austin.

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CHRISTOPHER BISE holds degrees in mining engineering from Virginia Tech and Penn State, and is a registered professional engineer in Pennsylvania. He previously worked for Consolidation Coal Company and was a resident engineer at two underground mines in Ohio. Dr. Bise received the College's Wilson Award for Outstanding Teaching earlier this year.

JAN MUTMANSKY has been with Penn State since 1977, and prior to 1981 served as mining center coordinator at the Fayette campus. He holds three degrees in mining engineering from Penn State. Dr. Mutmansky has worked with the U.S. Bureau of Mines and Kennecott Copper Corp., and held faculty appointments at the University of Utah and West Virginia University.

COLLEGE NEWS NOTES

College Holds Commencement

This year, in an attempt to counteract the disconcerting feeling of mass production that inevitably accompanies the graduation of a class at a large public university, Penn State has changed to a system of separate graduation ceremonies for each college. The college commencements held in May 1985 were so successful that this will probably become the standard pattern for the University.

The College of Earth and Mineral Sciences conducted a ceremony in Eisenhower Auditorium for its approximately 270 students of the Class of 1985 who had earned bachelor's degrees. In the presence of Dr. Bryce Jordan, president of the University, Edward R. Book of the Board of Trustees, and a large number of impressively robed faculty, individual recognition was given to each of the graduating students. The student marshal was Lynn D. Dietz, geosciences, and the engineering honor graduate was Gary, J. Carinci, metallurgy.

The commencement address was given by Dr. Charles L. Hosler, former dean of the college and now vice president for research and dean of the Graduate School, who spoke on the vital role played by negotiation in our society, and the importance of students acquiring the negotiating skills that will allow them to operate effectively in their careers.

Dr. Bryce Jordan, president of the University, speaking at the Spring 1985 commencement of the College of Earth and Mineral Sciences.

Ceramic Scientists Honored

With more than 5,600 people in attendance, the 1985 meeting of the American Ceramic Society was the largest technical ceramics event ever held in the United States. At this 87th annual meeting of the society, Penn Staters chaired 8 individual sessions, and 48 papers were presented by Penn State faculty, researchers and students from the College's Department of Materials Science and Engineering and the University's Materials Research Laboratory. **Richard E. Tressler**, chairman of the College's Ceramic Science and Engineering Program, was installed as chairman-elect of the ACerS Basic Science Division.

Honors were awarded to several Penn State faculty. **Rustum Roy**, Evan Pugh professor of the solid state, delivered the annual Edward Orton Jr. Memorial Lecture, speaking on "The Ambivalent Role of Technology in the Future of America and the World." **John J. Mecholsky**, associate professor of ceramic science and senior research associate in the University's Applied Research Lab, received the 1984 Karl Schwarzwalder Award for Professional Achievement in Ceramic Engineering. The 1985 Ross Coffin Purdy Award was presented

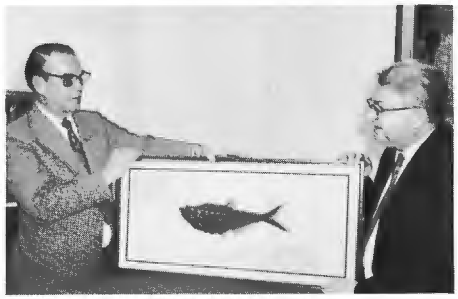
Graduate student Parmadath Lutchmansingh explains the operation of the Simtran Oil Rig Simulator to Dr. John C. Calhoun, former head of Petroleum and Natural Gas Engineering; Dr. Turgay Ertekin, current head of the Petroleum and Natural Gas Engineering Section, is on the right.

Key Alumni Weekend

More than one hundred of Penn State's most distinguished alumni returned to the University Park campus in March for three days of seminars, discussions, and blue-ribbon social activities. The event "Key Alumni—A Measure of Excellence" was heralded as an unprecedented success by both hosts and visitors.

Nine distinguished alumni visited the College of Earth and Mineral Sciences: **William Bellano,** '36 mining engineering, an internationally recognized energy resource expert, formerly president of Occidental Petroleum Company; **John C. Calhoun Jr.,** '37, '41, '46 petroleum and natural gas engineering, formerly head of PNGE at Penn State and now deputy chancellor emeritus at Texas A&M University; **George P. Cressman,** '41 meteorology, director of the National Weather Service for 14 years; **Robert L. Elmore,** '41 science, owner and director of major construction companies in Florida; **Edward G. Fox,** '25, '30 mining engineering, formerly president of Reading Anthracite Company and a distinguished leader in the coal industry; **Thomas M. Krebs,** '49 metallurgy, a specialist in tubular products and formerly group executive of Babcock & Wilcox Company; **Jay S. "Tiny" McMahan,** '24 commerce and finance, in his day a noted Penn State athlete and later a leader in blast furnace technology; **Allen S. Russell,** '36, '37, '41 chemistry, formerly vice president and chief scientist of ALCOA and now adjunct professor at the University of Pittsburgh; and **George E. Trimble,** '42 PNGE, president of R.J. Reynolds Energy Corporation and formerly president of Aminoil.

Dr. Alfred K. Blackadar, professor of meteorology, left, Dr. Charles L. Hosler, former dean of the College, center, and Dr. George P. Cressman, former director of the National Weather Service, enjoy their discussions in the Penn State Weather Station.



George E. Trimble, president of R. J. Reynolds Energy Corp., left, brought a gift for the Earth and Mineral Sciences Museum: a fine specimen of a fossilized Diplomystus, *a Middle Eocene fish from the Green River Formation, Wyoming. David Snell, museum curator, is shown on the right.*

Dr. John Hoke, chairman of the Metallurgy Program, left, in discussion with Dr. Lee Cuddy, associate professor of metallurgy, center, and Dr. Allen Russell, formerly chief scientist of ALCOA, following a seminar meeting in the Department of Materials Science and Engineering.

to **Yao Xi, Herbert A. McKinstry,** and **Leslie E. Cross** for their paper, "The Influence of Piezoelectric Grain Resonance on the Dielectric Spectra of LiNbO3 Ceramics," which appeared in the September 1983 issue of the society's journal. Dr. Yao, '82 Ph.D. solid state science, is now head of the Department of Electronic Engineering at Xian Jiaotong University, China. Dr. McKinstry is associate professor of solid state technology, and Dr. Cross is professor of electrical engineering.

Penn State alumni were among the new Fellows of the society honored at the awards luncheon: **William S. Bates,** '42, vice president of sales and administration and a member of the board of directors of Spectrochemical Labs, Inc.; **David W. Johnson Jr.,** '64, '68 Ph.D., supervisor of advanced ceramic processing for AT&T Bell Labs and an adjunct professor at Stephens Institute of Technology; **Robert C. Pohanks,** '72 Ph.D., program manager for nonmetallic materials at the U.S. Office of Naval Research; **Jay R. Smyth,** '74 Ph.D., development specialist in advanced propulsion technology at Garrett Turbine Engine Co.; and **Takeshi Takamori,** '72 Ph.D., research staff member at IBM's Thomas J. Watson Research Center.

Annual AAG Meeting

Penn Staters were a dominant force at the annual meeting of the Association of American Geographers, held in Detroit in April. The outgoing president of the society, **Peirce Lewis,** handed the baton to another member of the Department of Geography, **Ronald Abler,** who became AAG president for 1985/86. Waiting in the wings is president-elect **George Demko,** who received his doctorate from Penn State in 1963. Other elected officers of the society include **C. Gregory Knight,** department chairman, as chairman of the national nominations committee and **Alan MacEachren,** newly appointed assistant professor of geography, as chairman of the cartography specialty group.

Eight members of the Penn State faculty gave papers and participated in panel discussions, as did two current students, Cecyle Trepanier and Luann Hamilton. Penn State geography alumni participating in the meeting included: David Cuff (Temple University), Gregory Elmes (West Virginia University), David Goldenburg (Center for Health Policy Studies), David Hodge (University of Washington), Ben Marsh (Bucknell University), Grady Meehan (University of North Carolina), James Meyer (University of Chicago), Mark Monmonier (Syracuse University), John Pickles (Ohio University), Mary Beth Pudup (University of California-Berkeley), Ryan Rudnicki (University of Nebraska), Noriyuki Sugiura (Keio University, Japan), Robert Thomas (Michigan State University), and Richard Ulack (University of Kentucky).

Faculty Activities

C. Gregory Knight, professor of geography, made an extensive lecture tour of universities in central and east Africa sponsored by the U.S. Information Service, Penn State's Office of International Programs, and the College of Agriculture. Important objectives of his visit to Cameroon, Congo, Swaziland, and Kenya were to maintain contact with African faculty and university administrators who already have links with Penn State, and to identify scholars interested in doing doctoral and postdoctoral work here.

R.V. Ramani, professor of mining engineering, recently served as a consultant to the United Nations to assist the Indian Bureau of Mines in establishing a training center and training programs for Bureau employees and the Indian mining industry.

William R. Bitler, professor of metallurgy, has received a Fulbright grant from the program of educational exchange between the United States and Norway and will spend the 1985-86 academic year at the University of Oslo, Institute of Physics working with Dr. Jens Lothe, professor of physics, on a theoretical investigation of critical currents in type II superconductors and the interrelations of grain boundary motion and diffusion.

Hans A. Panofsky, professor emeritus of meteorology, has been elected an Honorary Member of the Royal Meteorological Society, U.K., for his distinguished work in meteorology.

Lee W. Saperstein, professor of mining engineering, has been appointed to the Committee on Abandoned Mine Lands, which will function under the Board on Mineral and Energy Resources of the National Research Council's Commission on Physical Sciences, Mathematics, and Resources and conduct a comprehensive study of the Abandoned Mine Lands program of the Office of Surface Mining.

Toby H. Carlson, professor of meteorology, is spending a sabbatical leave at the Centre de Recherches en Physique de l'Environment (CRPE) in Paris. He is working with a group of

French scientists to develop methods for remote measurement of surface water in soil, using infrared surface temperature measurements.

Paul C. Painter, professor of polymer science, has received the National Science Foundation's Outstanding Performance Award after serving a 16-month term as director of the NSF Polymer Program in Washington D.C. As program director, Dr. Painter was responsible for the review of research proposals and the disbursement of more than $6 million in research funding.

E. Willard Miller, emeritus professor of geography and associate dean emeritus for resident instruction, is the author of *Physical Geography: Earth Systems and Human Interactions*, an introductory student text published by Charles E. Merrill, Columbus, Ohio. The book is profusely illustrated with maps and graphs produced in the Deasy GeoGraphics Laboratory at the College's Department of Geography.

Robert G. Jenkins, associate professor and chairman of the Fuels Science Program, recently attended a conference, "Structure and Reactivity of Coal," of the Society of Chemical Industry, U.K., in London. Dr. Jenkins gave a paper titled "Reactivity of Rapidly Heated Coals," which was co-authored by D.J. Maloney.

Jeffrey L. Kohler, assistant professor of mining engineering, presented an invited paper on "Expert Systems in Mining" at the first Symposium on the Theory and Application of Expert Systems in Emergency Management, held in Washington D.C., and sponsored jointly by the National Bureau of Standards and the Federal Emergency Management Agency.

David J. Green, associate professor of ceramic science and engineering, attended a Transformation Toughening Workshop in Lorne, Victoria, Australia and gave two invited papers, "Flaw Populations in Transformation Toughened Materials" and "The Effect of Surface Stress on Indentation Cracking."

Gregory S. Forbes, associate professor of meteorology, was a leading member of the team of meteorologists who carried out aerial and ground surveys to analyze the tornado damage in Pennsylvania, Ohio and Ontario following the dramatic storms on May 31, 1985. The work was authorized by the National Weather Service and the National Research Council.

Robert E. Newnham, professor of solid state science, has been named National Lecturer for the Group on Sonics and Ultrasonics of the Institute of Electrical and Electronics Engineers (IEEE). Dr. Newnham will be available during 1985-86 to present lecturers on "Transducers, Sensors and Actuators" to appropriate local interest groups.

Theses Now Available

The following is a listing of advanced degree recipients and thesis titles from the Spring 1984 graduation of students from the College of Earth and Mineral Sciences. Requests to borrow theses or reports must be made through a library. Libraries should address requests to: Interlibrary Loan Service, Pattee Library, The Pennsylvania State University, University Park, PA 16802.

(There is a deliberate delay built into our announcement of thesis titles to allow for binding and cataloguing by the University library—the added delay in presenting these theses was due to lack of space in subsequent issues of *Earth and Mineral Sciences*—ed.)

Ceramic Science—Daniel Franke Carroll, M.S., *Flaw Behavior in Siliconized Silicon Carbide at Elevated Temperatures Under Static Load;* Dennis Norman Coon, M.S., *Some Mechanical Properties of Nitrided Sodium-Borosilicate Glasses;* Gregory Scott Corman, Ph.D., *Phase Equilibria, Defect Ordering and Ionic Conductivity in the Zirconia-Ytterbia-Yttria System;* David James Voss, M.S., *Ferroelasticity in Synthetic Leucites.*

Fuel Science—Michael Richard Bogdan, M.S., *Characterizing Coal via Laser Pyrolysis Mass Spectrometry;* Richard Edmund Conn, M.S., *A Preliminary Study of the Sintering Characteristics of Coal Ash as Related to Utility Boiler Ash Deposition;* Scott Michael Smouse, M.S., *Effect of Oxygen Enrichment on Nitrogeneous Emissions from Flames of Petroleum- and Coal-Derived Distillate Fuels;* Yukihiro Sugimoto, M.S., *The Puffing of Calcined Cokes During Graphitization.*

Geochemistry and Mineralogy—Charles Stewart Eldridge, Ph.D., *A Sulfur Isotopic, Ore Textural, Chemical, and Experimental Study on the Formation of the Kuroko Deposits, Hokuroku District, Japan;* Andrew Paul Gize, Ph.D., *The Organic Geochemistry of Three Mississippi Valley-Type Ore Deposits;* Kenneth Michael Krupka, Ph.D., *Thermodynamic Analysis of Some Equilibria in the System* MgO-SiO_2-H_2O*;* Gregory Albert Merkel, Ph.D., *Thermodynamic Mixing Properties of Binary Analbite-Sanidne Feldspars;* James Bernard Murowchick, Ph.D., *The Formation and Growth of Pyrite, Marcasite, and Cubic FeS;* Anne Pavelka, M.S., *Trends in the Variations of Metal Ratios with Ore Type and Stratigraphic Position in the Kuroko Deposits, Japan;* Janet Ann Schramke, Ph.D., *The Kinetics of Metamorphic Hydration-Dehydration Reactions;* Stephen Bruce Tanner, M.S., (paper) *Experimental Kinetic Study of the Reaction: Calcite + Quartz ‹’ Wollastonite + Carbon Dioxide, at Geologically-Relevant P-T Conditions;* Sarah Rose Werner, M.S., (paper) *The Role of Tellurium in Hydrothermal Gold Transport.*

Geography—Shari Chaya Wasser, M.S., *Pica or Elite: A Geographical Perspective on Lead Poisoning.*

Geology—Sharon D. Allshouse, M.S., *Petrographic Variation Due to Depositional Setting of the Lower Kittanning Seam, Western Pennsylvania;* Kathleen Mary Gerety, Ph.D., *A Wind-Tunnel Study of the Saltation of Heterogeneous (Size, Density) Sands;* Karen Lund, Ph.D., *Tectonic History of a Continent-Island Arc Boundary: West-Central Idaho;* William Ferrell McCollough, M.S., *Stratigraphy, Structure, and Metamorphism of Permo-Triassic Rocks Along the Western Margin of the Idaho Batholith, John Day Creek, Idaho;* Anthony Robert Prave, M.S., *Stratigraphy, Sedimentology, and Petrography of the Lower Cambrian Zabriskie Quartzite in the Death Valley Region, Southeastern California and Southwestern Nevada.*

Geophysics—Eric George Hilbert, M.S., (paper) *Ultrasonic Measurements of the Elastic Properties of Single-Crystal Magnesium Aluminate Spinel,* $MgAl_2O_4$*;* Robert Mark Ossman, M.S., (paper) *Seismotectonics of Southeastern New York State.*

Meteorology—John Michael Lanicci, *The Influence of Soil Moisture Distribution on the Severe-Storm Environment of the Southern Great Plains: A Numerical Study of the SESAME IV Case;* Thomas J. Rappolt, M.S., *Interpretation of Extraterrestrial Images to Obtain the Vertical Temperature Profile;* Michael Phillip Seidel, M.S., *The Impact of Appalachian Damming on Approaching Cyclones and Implications for Objective Weather Forecasts;* David Ralph Stauffer, M.S., *A Real-Data Numerical Study of the Lower-Tropospheric Structure Associated with Cold-Air Damming and Coastal Frontogenesis;* Quin Xu, Ph.D., *Conditional Symmetric Instability and Mesoscale Rainbands.*

Metallurgy—Kwang Lung Lin, Ph.D., *Interfacial Charge, Micellization and Mass Transfer in Hydrometallurgical Solvent Extraction: A Hydroxyomine-Sulfonic Acid Mixed Extractant System;* Udaybhanu Pal, Ph.D., *Reaction of* PbO-SiO_2 *Melts With Gases;* Thomas Rajah Parayil, M.S., *Continuous Recrystallization In a Duplex Stainless Steel;* Joseph Anthony Sychterz, III, M.S., *Inclusion Control in a Continuous Casting Tundish;* Tao Xue, M.S., *Electrochemical Behavior of Gold, Silver, and Gold-Silver Alloys in Cyanide Solutions.*

Mineral Economics—Kenneth Wayne Boras, M.S., *The Effect of Price Controls on the Natural Gas Market;* Raymundo Miguel Valdes Flores, Ph.D., *The Use of Production Functions to Model Copper-Aluminum Substitution in the Electrical Conductor Industry;* Bok Jae Lee, M.S., *Analysis of the Regional Economic Benefits and Costs of a Severance Tax: The Case of Georgia Kaolin;* Ciel Lee Pettit, M.S., *The Costs of Controlling Utilities'* SO_2 *Emissions;* John Howison Schroeder, M.S., *The Surface Mine Reclamation Bonding Program in Pennsylvania: A Cost Analysis of the Bonding Alternatives, and an Evaluation of the Program.*

Mining Engineering—Ragula Bhaskar, M.S., *A Mathematical Model for the Prediction of Ambient Dust Concentrations in Mine Atmospheres;* Arnis Mangolds, M.S., *Residual Stresses in Halite;* Thomas Novak, Ph.D., *The Analysis of Mine Electrical Systems for the Protection of Maintenance Personnel;* Nilo Rios Quinteros, M.Eng., (paper) *Risk Recognition Evaluation and Management in the Mineral Industry.*

Petroleum and Natural Gas Engineering—Mustafa Bayram Biterge, M.S., *Performance of Pure Penn State Surfactant Systems in Consolidated Porous Media;* David John Remner, M.S., *Numerical Investigation of the Competing Effects of Water, Relative Permeability and Sorption Characteristics of Coal Seams in Methane Drainage Processes.*

Polymer Science—Brian David Hanrahan, M.S., *The Effect of Morphology on the Mechanical Properties of Polymers;* Thomas David Juska, Ph.D., *Plasticity in Polymers;* Brian George Landes, Ph.D., *The Crystallization of Copolymers;* Elizabeth Sarah Berman Riesser, Ph.D., *The Determination of Aromatic and Aliphatic C-H Groups in Coal Using Fourier Transform Infrared Spectroscopy.*

Solid State Science—T. R. Gururaja, Ph.D., *Piezoelectric Composite Materials for Ultrasonic Transducer Applications;* Arvind Halliyal, Ph.D., *A Study of the Piezoelectric and Pyroelectric Properties of Polar Glass-Ceramics;* Christos Gotsis, Ph.D., *ATHENAN: Axisymmetric Thermal Nonlinear Analysis—A Computer Program for Cements and Other Chemically Reactive Cylindrical Domains and Associated Computer Graphics Algorithms;* Kurt Michael Rittenmyer, Ph.D., *Electrostriction in Cubic Halide Compounds;* Carole Lynne Sundius, M.S., *Direct Measurement of the Temperature Dependence of Electrostrictive Coefficients in Strontium Barium Niobate.*

Upcoming Events

Taylor Lectures

The 1985 Taylor Lecture Series will be held in Kern Graduate Building on the University Park Campus on September 26 and 27. This year's speaker will be Dr. Julian Szekely an eminent metallurgist and materials scientist who is professor of materials engineering and associate director of the Center for Materials Processing at the Massachusetts Institute of Technology.

Dr. Szekely will speak on, "High Technology—Will it Save the Steel Industry?" and "The Mathematical and Physical Modeling of Metals Processing Operations."

His work in mathematical and physical modeling of materials processing operations has been recognized by numerous awards in the United States and the United Kingdom, most recently (1983) the Charles H. Jennings Memorial Medal of the American Welding Society. He holds the D.Sc. degree of the University of London, and in 1982 was elected to membership of the National Academy of Engineering. He is author of four well-known textbooks.

Further information can be obtained from the Department of Materials Science and Engineering, 101 Steidle Bldg.

Ceramics Meeting

The 40th anniversary meeting of the Pennsylvania Ceramics Association will be held at University Park on October 10 and 11. On Thursday, October 10 there will be a poster session and research open house in the Art Gallery and Museum of the College of Earth and Mineral Sciences from 2 p.m. to 5 p.m. On Friday, October 11 there will be a technical meeting on the technology and applications of low temperature ceramic processing, followed by a banquet. Those wishing further information should contact Dr. Guy Rindone, 116 Steidle Building, PSU.

Metallurgy Coop Meeting

The 50th anniversary meeting of the Cooperative Program in Metallurgy will be held October 4th.

9:00 a.m. Technical Presentations in Keller Conference Center

2:00 p.m. Open House in Metallurgy in Steidle Building

7:30 p.m. Dinner in the Nittany Lion Inn.

Joint MIT/PSU Program Announced

Meeting at MIT following the signing of the joint education and research agreement are: (left to right): Dr. John F. Elliot, director, Mining and Mineral Resources Institute at MIT; Dr. Lee W. Saperstein, head, Mining Engineering Section, PSU; Dr. Paul E. Gray, president of MIT; and Dr. Carl R. Peterson, Department of Mechanical Engineering, MIT.

Penn State and the Massachusetts Institute of Technology, in a first-ever cooperative venture, are seeking ways to harness recent technological advances in the service of improved productivity and safety in mines.

Through a joint research and education program, the two institutions have established the **Center for Innovative Mining Systems** which will combine MIT's leading capabilities in materials behavior, mechanical design, and controls with the expertise in mining research and technology of PSU's Department of Mineral Engineering. Directing the project are Dr. Carl R. Peterson, Department of Mechanical Engineering at MIT and Dr. Lee W. Saperstein, head of the Mining Engineering Section in the College of Earth and Mineral Sciences. Faculty and graduate students in the Department of Mineral Engineering will participate in the program.

The driving force behind the new Center is Carl Peterson, associate professor of mechanical engineering at MIT, who founded the Laboratory for Mining Systems Development at the Boston institution in 1980. Dr. Peterson feels that the slow evolutionary pace of innovation in mines, where each small change is grafted on to existing mine systems and constrained by traditional practices, is inappropriate for accommodating the revolutionary developments in sensing and control and computerized technology that have taken place in recent years.

He contends that a new impartial examination must be made of existing methods and equipment, and that entire systems should be redesigned in light of recent innovations. He is confident that improved equipment can be developed that will offer greater safety to mine workers as well as higher productivity. Dr. Peterson first sought Penn State cooperation in his quest in 1982, and the new Center is an outgrowth of the ensuing discussions.

Initial research at the Center will examine ways to simplify underground mining systems and focus on using remote control, and innovative machines and methods to excavate mine entries in a truly continuous and more rapid operation. There are also long-range plans to develop new graduate and continuing education courses and establish cooperative programs with industry.

The Center's research thrust will be explored in the 1st International Symposium on Innovative Mine Systems, to be held at MIT on November 4 and 5, 1985. Participation by the industry is invited.

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Arnulf Muan, *Editorial Director*
Judith Kiusalaas, *Editor*

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