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Atmospheric Measurement Techniques for Supplementary Control System Strategies

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The atmosphere varies tremendously in its ability to disperse the emissions from the tall smoke stacks of large, coal-fired power generating plants.

Actual air quality measurements made at such plants have shown that, most of the time, contrary to current air quality requirements, the plants could burn high-sulfur coal without unduly taxing the atmosphere. It would be necessary to burn the less abundant and more expensive low-sulfur coal only at those times when monitoring instruments indicated the existence of decreased wind speed and inversion conditions that would not allow the atmosphere to disperse the emissions from high-sulfur coal quickly enough for environmental safety.

This technique for making use of our high-sulfur coal has been advanced by various experts and agencies as a method of operation for large power plants along the east coast. Any acid rain that might occur as a result of the increased sulfur dioxide emissions from these plants, it is maintained, would be carried offshore by

Continued on next page

Sears, Satellite & Company?

RONALD ABLER, *Head, Department of Geography*

The nineteenth century saw spectacular innovations in transportation. In 1800, the maximum sustainable speed that people or materials could move over long distances was 10 miles per hour. By 1900, large numbers of people and masses of materials could be transported for thousands of miles, at speeds averaging 60 miles per hour, with great security and certainty. Jules Verne captured the end-of-the-century wonder over what transportation had wrought in *Around the World in 80 Days.*

Better transportation permitted major changes in the economic and settlement geographies of the industrial nations. In America, separate regional units were knit into a single national economy by the 1880s. Rail transportation made it possible for firms to organize operations over several states, and eventually the entire nation. After the Civil War, people began to move easily and freely among all parts of the nation for social, recreational, and economic reasons. The assembly of large numbers of

Continued on page 42

Aerial view of Hoover Dam and Lake Mead, Boulder Canyon Project, in Arizona-Nevada—earthquakes associated with the impoundment of this reservoir were the first to be documented as reservoir-induced. (DOE photo)

Reservoir-induced Seismicity—Those Dam Earthquakes

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Achieving a better understanding of the occurrence and mechanism of earthquakes is a major problem in the natural sciences that requires a truly interdisciplinary approach.

In general, the crust-mantle-earthquake system is only poorly understood because much of what we know about the earth's detailed physical properties is confined to the upper few kilometers. The phenomena of earthquakes associated with the impoundment of large reservoirs represents an unusual and sometimes disconcerting opportunity to investigate some of the properties of this system.

On a global scale, the location of earthquakes is nicely explained by the theory of plate tectonics. In principle, it is widely accepted that the relative natural movement of large but thin lithospheric plates against each other causes discontinuities or faults in the displacement field and, if these faults move on time scales of a few seconds, this movement can cause

Continued on page 41

Control Strategies—

Continued from first page

the prevailing westerly flow of air and eventually fall in the ocean. The amount of acid deposited in the Atlantic would not be noticeable, and, by the time the air would reach Europe, it would be cleansed.

Successful application of this technique of switching from low-sulfur to high-sulfur coal in response to changing atmospheric conditions, were it to be permitted by the Environmental Protection Agency, would depend upon the operation at the power plant of combined instrumentation and models which together are called a supplementary control system (SCS). The SCS is designed to insure that emissions from a given source will not cause the quality of the air around that source to deteriorate below the required standards during varying meteorological conditions.

Although national air quality regulations presently require that primary emission controls be of a "removal" nature (from the fuel or at the stack) rather than of a control nature, economic (as to fuel type, availability, and cost) and political (such as the use of nuclear power) considerations are certain to motivate reconsideration of SCS techniques. This will be true particularly in coal mining areas where relatively large numbers of coal-fired electrical power plants are located and synthetic liquid fuel plants are likely to be built.

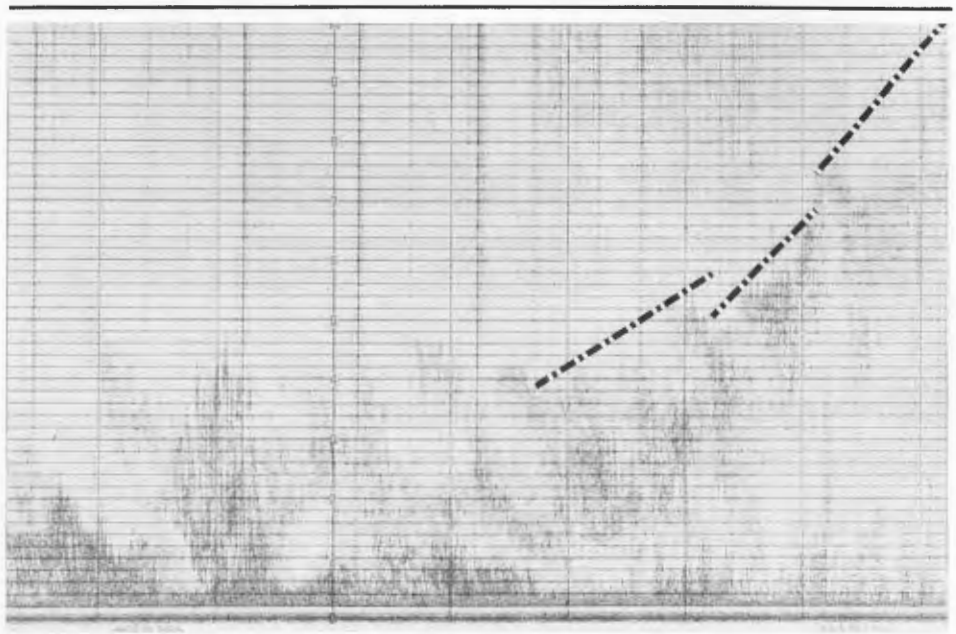

Figure 1. Sodar record of mixing layer depth (surface to 1 kilometer) versus time (midnight to 8 a.m.) observed on May 16, 1979, at Penn State's Rock Springs Agricultural Research Center near the University Park Campus. The increase in the height of the mixing layer after sunrise can be seen on the righthand portion of the illustration with the highest points delineated by the dashed lines.

As exemplified on a daily basis by our changeable weather, the atmosphere as a depository into which residual sulfur-dioxide and other waste products must be dumped is highly variable—with regard to both space and time. Fortunately, both our understanding of the meteorological processes and atmospheric structure and our ability to make measurements of these has advanced significantly in the last decade. This paper summarizes some of the advances relevant to SCS technology to which research in the College of Earth and Mineral Sciences at Penn State has made significant contributions.

Definition of the Atmospheric Depository

The length of the atmospheric "box" into which pollutants are deposited downwind of a specific emission source depends, basically, upon the speed of the wind. Determination of the average wind speed and direction, which is equivalent to defining the box length and orientation, is generally sufficient to define processes that transport the pollutants. The width of the box, however, depends upon diffusion processes which are related to fluctuations in wind speed and direction. Although the depth of the box is determined by vertical diffusion processes, diffusion upward is effectively limited by a shallow, relatively stable layer of air that normally caps the so-called planetary boundary or "mixing" layer. At altitudes of more than two kilometers, the effects on the atmosphere of the proximate earth's surface may essentially be ignored without adversely affecting, for example, an aviation weather forecast.

However, the structure of the mixing layer and processes occurring within it depend not only upon current weather conditions but also upon the complicated topography of and the micrometeorological processes occurring at the earth's surface. It is in the highly variable mixing layer that we live and into which most pollutants created by man are emitted.

Depending upon the location and weather conditions, in the course of a day, the mixing layer, z_i in Figures 1 and 2 may be as shallow as 30 meters or deeper than 2 kilometers which means that its depth may vary by a factor of more than 70. In central Pennsylvania (Figure 1), diurnal variations of the mixing layer are an order of magnitude, typically from 150 to 1500 meters.

Although analysis in detail of the variations with time of the mixing layer is the subject of ongoing research, its general diurnal behavior is well understood. Hence, for pollutants emitted close to the surface, such as automobile (or wood-burning stove) exhausts, local air quality conditions in and downwind of an urban area can often be satisfactorily evaluated using a simple "box" model as outlined above.

However, in the case of a large point source such as a power plant, adequate determination of how the box size varies with time can not be satisfactorily inferred from larger-scale weather maps, from observations made only at the earth's sur-

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face, or by using economically viable instrumented towers.

Power plant stack heights are typically 800 to 1000 feet (250 to 312 meters). But since the stack gases are buoyant, warmer than the surrounding air, they will rise to the so-called effective stack height at which the gas and atmospheric temperatures are equal. This means that at night pollutants are emitted into the atmosphere above the height of the mixing layer; sometime during the day, the mixing layer and the effective stack height will coincide; then, until about sunset the effective stack height will be less than the depth of the mixing layer (Figure 2). The decision by the Environmental Protection Agency to discourage supplementary control system strategies for air pollution control was probably strongly influenced by recognition of: (1) the "megabuck" costs of acquiring mixing layer measurements using conventional tower-mounted or airborne (aircraft or balloon) temperature and wind sensors, and (2) the lack of adequate diagnostic and prognostic models appropriate for fast (real-time) analyses of pollutant transport and diffusion in the mixing layer. Both mixing layer modeling and measurement techniques have long been the subject of meterological research at Penn State. Within the past year, we have been successful in developing a computer-based measurement system which, it now appears, can solve most practical mixing layer diagnosis and prediction problems. We call this system the Computerized Acoustic Sounding System.

The Penn State Computerized Acoustic Sounding System

The Penn State Computerized Acoustic Sounding System (CASS) consists of a unique combination of mixing layer diagnostic and prediction models that are run in the minicomputer which also controls and processes data from an integrated, sophisticated Doppler sodar (*so*nic *d*etection *a*nd *r*anging) system.

Since their development in the late 1960s, sodar systems have become widely accepted as "semi-quantitative," remote probes of the lower atmosphere. Nearly a thousand sodar units have been commercially produced and distributed throughout the world. However, the basic commercial systems provide quantitative information only on the depth of the mixing layer. Information on the relative stability of different atmospheric layers, which control vertical diffusion rates at various heights, may be only "qualitatively" inferred.

Doppler sodar systems that can also determine wind speed and direction as a function of height are now being commercially marketed. However, unambiguous interpretation of sodar records—like

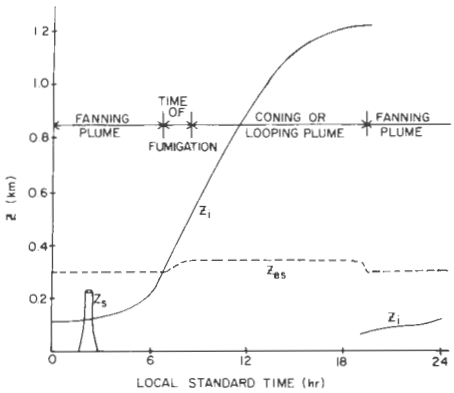

Figure 2. Schematic diagram of mixing layer depth and typical associated effective plume height and type versus time of day. z_s is stack height, z_{es} is effective stack height, and z_i is the upper boundary of the mixing layer.

those from weather radars—currently requires a highly trained observer. Furthermore, the system outputs, at best, are still "intermediate" meteorological variables which then must be separately applied to the user's particular air pollution measurement or modeling problem.

In the CASS system, many of the tasks previously requiring the effort of a professional meteorologist have been programmed into the sodar system computer. The challenge in developing such a system was in finding ways to extract from the received sodar signals the information necessary for the various air-pollution-related, meteorological models.

As indicated earlier, the transport of pollutants is dependent upon the mean wind speed. Although extensive computer processing of the Doppler-shifted received signals is required, sodar can now be readily used for wind measurements. Up to heights of about 300 meters, the maximum height of costly instrumented towers, the wind speed and direction can be determined just as well by sodar as with conventional anemometers and wind vanes. Above tower heights (300 meters to 1 kilometer), wind measurements made by sodar are far superior to those determined by use of the so-called "pibal" balloons which must be manually tracked with a theodolite.

However, both the rise of a buoyant plume from a power plant to the effective stack height and the plume's vertical diffusion depend upon the rate of change of temperature with height. This observation cannot be directly extracted from the sodar signals. The signals do depend, however, upon the magnitude of atmospheric temperature fluctuations which are in turn dependent upon the vertical temperature profile. By using a mixing layer model, we can relate the sodar signals to the vertical temperature profile. This is possible because the ambient temperature profile must be dynamically consistent with the change in wind speed with height, and also with the magnitude of the turbulent wind and temperature fluctuations with height—both of which are observable using the sodar.

Mixing or boundary layer models which can be used for diagnosis and prediction of wind, temperature, and turbulence profiles as a function of time cover a wide range in their degree of complexity and the cost of their application. A research mixing layer model used to test and evaluate simplified models that are appropriate for air pollution applications can require as much as 350 hours of time on a large computer for the numerical simulation of the evolution of the boundary layer for a single 24-hour period. Application of such a research model for operational purposes is logistically and economically out of the question. Fortunately, in the last five years a number of simplified models have been developed.

At Penn State Dr. A. K. Blackadar, professor and head of the Department of Meteorology, Dr. Hendrick Tennekes now director of research at the Royal Netherlands Meteorological Institute, and others, have gained world-wide recognition for their work in developing simplified models for simulating the growth and daily evolution of the mixing layer. Application of several of these Penn State models in the CASS system was thus not simply a matter of geographic convenience but rather, and more importantly, the adoption of a sound, widely accepted methodology.

CASS applied to SCS

Let us for the moment, limit the applica-

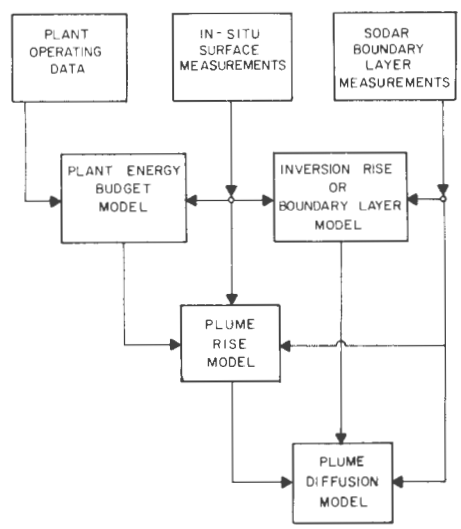

Figure 3. Block diagram of the Penn State CASS system. The sodar system computer includes all the functional elements with the exception of the plant operating data and the surface measurements. Both of the latter could also be automatically put into the system computer.

tion of CASS to the following special SCS problem: predictions of the time of fumigation (coincidence of the mixing layer depth and effective stack height) and the downwind surface concentrations of SO_2 from a power plant. With these predictions in hand, the plant operator will be able to determine whether or not it will be possible on a given day to burn less expensive, higher-sulfur coal. The plant operator may employ CASS, as shown in the block diagram in Figure 3, in the following manner.

First, with the exception of an initial temperature sounding, all of the required input data (observations) are normally available or easily measurable at the power plant using conventional instruments and a sodar system. Fortunately, the local (in a geographic sense) characteristics of early morning vertical temperature profiles are, typically, limited to about 10 percent of the eventual total mixing layer depth. Normally, temperature-sounding data from the nearest National Weather Service radiosonde station are adequate for beginning computations with the model. Lacking radiosonde data, a suitable temperature sounding could be inferred from local surface observations and readily available network weather data. This is possible only because CASS has a unique "feedback" circuit in the inversion-rise, mixing layer model calculations which updates the sounding on the basis of the local sodar measurements.

The CASS computer determines the effective stack height by running a plume-rise model based on the data as shown in Part A of Figure 4. Immediately after the effective stack height is computed, an inversion rise model (such as one of those developed at Penn State) is run, using the data summarized in part B of Figure 4. Note that some of the required measurements are common to both the inversion rise and the plume-rise models. By combining the results of the two models, the operator will obtain an initial forecast of the time of fumigation which occurs when the height of the upward growing mixed layer reaches the level of the effective stack height. The effective stack height is typically several hundred meters and, thus, is such that fumigation is likely to occur between 9 and 11:30 a.m.

After sunrise, with the initial model predictions completed, the CASS monitors the actual inversion height and compares it with the earlier predicted height. If the mixed layer is observed to be growing at a different rate than was forecast, the CASS will modify, for example, the upward flux of heat and then rerun (update) the inversion-rise model. This process is repeated until the actual and predicted mixing layers coincide. Using the "updated output" of the inversion-rise

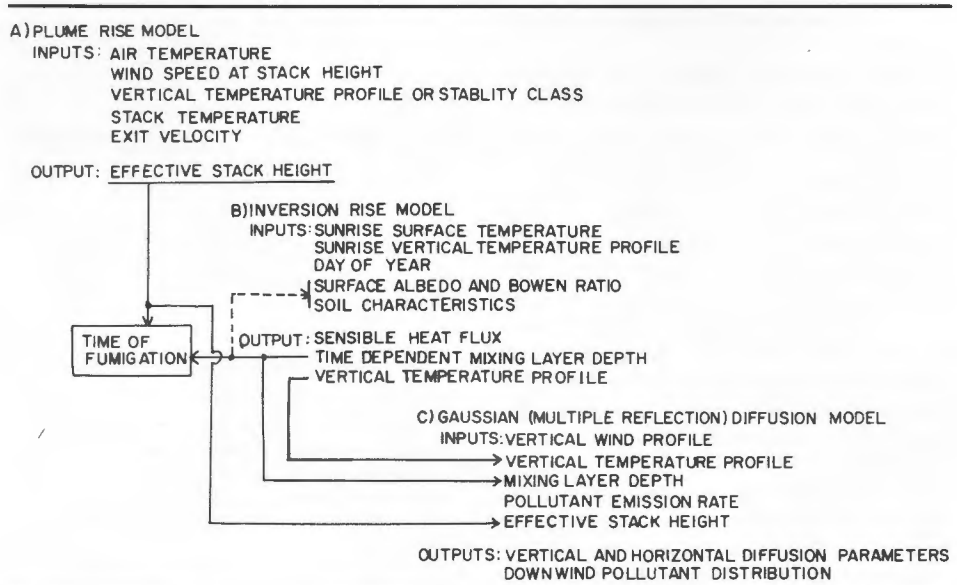

Figure 4. Summary of principal input-output parameters for models used in CASS. Solid lines denote use of model-predicted parameters in subsequent models. The dashed line shows the feedback scheme used to correct earlier predicted mixing layer depths with observed values.

model, the operator can expect an even more accurate estimate, for example, of the time of fumigation.

Presumably, a plant operator will be interested not only in the time of fumigation, signaling the onset of an event that may last only 30 minutes, but also the downwind spatial distribution of pollutants. Of particular importance is the maximum SO_2 concentration that will occur and its location. After fumigation has occurred, the surface SO_2 concentrations vary inversely with the height of the mixed layer. Hence, the surface concentrations will generally decrease as the day proceeds. It is the plume-dispersion model which provides the estimated concentrations by combining outputs from the plume-rise model, the inversion-rise model, and the other data presented in Part C of Figure 4. Figure 5 is an example in black and white of the color television display of pollutant concentration isopleths on the output of the CASS computer system.

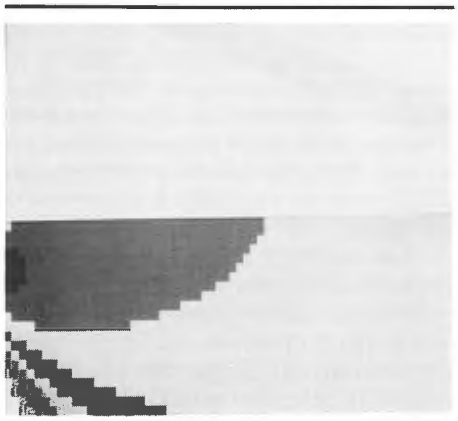

Figure 5. Reproduction of CASS color television display of the vertical cross section of pollutant concentration isopleths. The vertical axis is 0 to 500 meters and the horizontal axis is 0 to 20 kilometers. The source of pollution is at the left while the wind is blowing from left to right. The top of the mixed layer is clearly evident in the abrupt change near the top of the display.

As soon as the operator has the "updated output" from the inversion rise model, he uses the CASS computer to forecast concentrations for the remainder of the day. The estimated concentrations thus allow him to plan his control strategy; for example, he can predict the feasibility of switching to another coal without exceeding air quality standards in the vicinity of the plant. Repeated runs of the model would most likely be used to evaluate average surface concentrations over selected intervals such as 1-, 3-, or 24-hour periods.

Using CASS, it is thus possible, by about two hours after sunrise, to have sufficient information available to plan an entire day's fuel-burning strategy.

At the present time, techniques such as CASS are readily applicable to power plant or industrial sites that are known to be highly sensitive to local meteorological conditions. Looking to the future, such techniques are also well suited for urban and, perhaps, even regional-scale analyses. By substituting time-dependent "box" models for the single-plume models described here, predictions of atmospheric pollutant concentrations downwind of many geographically distributed sources are possible. Thus in critical situations such as major air stagnation episodes, it would be possible to make objective evaluations regarding the impact of specific pollutant sources on the atmosphere at any time.

Acknowledgments

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of Energy and Environmental Protection Agency. The assistance of Robert Peters, research assistant, in all aspects of the system development effort is gratefully acknowledged.

The Authors

Dr. Dennis W. Thomson completed his B.S. in physics in 1963, and his M.S. and Ph.D. in physics in 1964 and 1968, respectively, at the University of Wisconsin (UW).

Prior to joining the Penn State faculty as an assistant professor in 1970, he spent one year as a post-doctoral fellow at the University of Hamburg, West Germany, and one year as a member of the UW faculty. In 1977-78, while on sabbatical leave, he worked at the Riso National Laboratory near Roskilde, Denmark. He was promoted to professor in 1978. His research interests include indirect, principally acoustic, atmospheric measurements techniques, and the analysis and application of airborne and surface micrometeorological observations. He regularly serves on national advisory panels and committees concerned with environmental, industrial, and defense atmospheric measurements problems.

Mark J. Logan received his B.S. in meteorology from Penn State in 1978 and is currently working toward an M.S. in this field. His research interests include planetary boundary layer studies with particular emphasis on applications of remote sensing techniques.

Seismicity—

Continued from first page

earthquakes. In detail, however, plate boundaries are complex beasts that can be immediately appreciated by examining any good geologic map.

Fault zones that have been the locus of past earthquakes or are believed to be "capable" of producing large destructive earthquakes are seen to be a heterogeneous mixture, involving the juxtaposition of various geologic units of differing material properties and all sizes and shapes. A fault such as the San Andreas of California is not the idealized line one sees on a map but a general linear zone of complex en echelon and discontinuous structures.

Superimposed on this view of complex fault geometry are the unknowns of tectonic stress and the nonlinear behavior of geologic materials near failure. Although direct stress measurements have been done in recent years, they have been confined to the upper few kilometers and are not relevant to typical crustal earthquake depths. Laboratory measurements of the constitutive properties of geologic materials near failure have been and are actively being performed, but application of this data to the field situation is hampered by the complexity of the geologic system and the differing stress and displacement boundary conditions between the experiment machine and the earth. The net result of all this complexity is that, along plate boundaries, the spatial and temporal occurrences of most earthquakes are described well by statistical means rather than by some deterministic theory.

The natural "disorder" does offer tantalizing clues to the mechanism of earthquakes in the occasional instances in which man inadvertently perturbs the system. The results of these perturbations go under the heading of "induced seismicity" or its antithesis, "induced aseismicity."

Apparent changes in the seismicity of a region due to a change of the stress field or near-surface geometry have been noted from some mining activities, large underground nuclear explosions, fluid-injection experiments associated with oil wells or waste disposal, and impoundment of large water management reservoirs. Of these, perhaps reservoir-induced seismicity is the most dramatic. The accompanying table lists seven reservoirs which have apparently had major earthquakes associated with their impoundment. Shaking from the main earthquake associated with the Koyna, India, reservoir, for example, killed over 200 people and severely damaged the dam structure. In addition to these individual large events, there have been numerous associated foreshocks and aftershocks that have also caused damage to local structures.

Other major reservoirs have had small earthquakes associated with their impoundment and some, like Tarbela Reservoir in Pakistan, have apparently caused a decrease in the regional background seismicity. By far, most major reservoirs (with dam heights over 100 meters) have had no apparent effect on local seismicity. Only a small fraction (about 8 percent) have had apparent seismicity changes associated with impoundment, and only about 2 percent have had significant earthquakes. Because of the low incidence of reservoir-induced seismicity, it is plausible to dismiss such occurrences as statistical fluctuations. However, some of the better documented cases, such as those at Koyna or Kariba, leave little doubt of the causal relationship between impoundment and seismicity, suggesting that there are geologic or hydrologic peculiarities at those sites not normally found at other locations.

This LANDSAT satellite image of a portion of the west coast of India shows the Koyna reservoir (right center) which was the site of an induced earthquake of magnitude 6.5. Each side of the image is about 110 kilometers in length. The reservoir sits near the top of a fault-controlled topographic escarpment and experiences large seasonal fluctuations in water level.

Most physical theories proposed to explain reservoir-induced seismicity have the reservoir act as a triggering mechanism only. Pressures at the bottom of a 100-meter-high reservoir are only about 10 bars and, at earthquake hypocentral depths of 10 kilometers in the crust, load-induced stresses are only on the order of 0.1 bar. Water pore pressure changes in the crustal rocks may be as great as 10 bars, depending on what model geometry is considered, and could act to weaken rocks by also about 10 bars. Although the strength of crustal rock is probably lessened due to episodes of cracking and chemical action over long periods of time, these small induced stresses are still much smaller than are needed to cause fracture. Thus, it is believed that earthquakes associated with reservoirs are simply triggered tectonic events which probably would have happened anyway, given enough time.

From the literature, it is apparent that the seismological study of these unusual earthquakes is still in a rudimentary stage. A major part of the on-going research in which I am involved concerns the characterization of the seismic sources of major induced events. Recent advances in synthesizing the ground motion from dislocation-source models in realistic crustal structure has allowed more information to be extracted from seismic wave forms. Greater resolution of source depths, fault orientations, and the slip his-

RESERVOIRS THAT HAVE PRESUMABLY INDUCED SIGNIFICANT EARTHQUAKES

Dam	Location	Dam Height (meters)	Reservoir Volume ($x10^6m^3$)	Year of Impoundment	Year of Largest Earthquake	Magnitude
Koyna	India	103	2708	1964	1967	6.5
Kremasta	Greece	165	4750	1965	1966	6.3
Hsinfengkiang	China	105	10500	1959	1962	6.1
Oroville	U.S.A.	236	4295	1968	1975	5.9
Kariba	Rhodesia	128	160368	1959	1963	5.8
Hoover	U.S.A.	221	36703	1936	1939	5.0
Marathon	Greece	63	41	1930	1938	5.0

(from D. W. Simpson, "Seismicity Changes Associated with Reservoir Loading," Engineering Geology *10 (1976): 123-150.)*

tory across these faults is being obtained than was possible with previous standard and oversimplified seismological techniques. This information is useful, at the very least, for performing comparisons of the seismic sources from several reservoirs to determine any possible similarities. Work is also being done to characterize the tectonics and geology of the various regions using LANDSAT (satellite) imagery. This is a crucial aspect of the study due to the location of some reservoirs in largely unmapped areas.

In summary, the phenomenon and study of reservoir-induced seismicity is recent and, by its nature, very complex, comprising just a small subset of the general problem of the earthquake mechanism. The causal relationship between the natural earthquake-crust system and large-scale cultural activities offers tantalizing new clues into the physical processes of rock fracture and may eventually lead to control and prediction of destructive earthquakes.

The Author

Dr. Charles A. Langston joined the faculty of the Department of Geosciences in 1977 after receiving his Ph.D. in geophysics from the California Institute of Technology in 1976, and serving as a research associate there for a year. His current research interests are in the subjects of earthquake source mechanism and crustal and upper mantle structure.

Sears, Satellite—

Continued from first page

workers and large quantities of materials in huge industrial complexes produced the beginnings of the twentieth century industrial and commercial metropolis in places such as Pittsburgh, Detroit, and Chicago.

Building the facilities that made better transportation possible was an expensive undertaking: annual investments in railroad transportation alone amounted to 1 to 2 percent of the Gross National Product between 1870 and 1900.

Today, Americans are building another expensive technology that could affect our lives almost as much as railroads affected the nation in the latter part of the last century. In 1980, the U.S. telephone industry will spend almost $21 billion on new plant and equipment. Other communications enterprises will invest an additional $1 billion for communications facilities. If the pattern established over the last decade remains unchanged, the $22 billion spent by the communications industries will constitute 12 percent of all private sector investment in new plant and equipment during 1980, and almost 1 percent of the 1980 Gross National Product. The American economy is putting its money where its mouth (and eyes) is.

This heavy commitment to communications technology is proceeding much more unobtrusively than the last century's investments in rail transportation. Although proportionally smaller than the rail investments, this century's investments are of the same order of magnitude, and we can reasonably expect them to yield profound opportunities for changes in social, economic, and geographical patterns toward the end of the century.

Emerging Technologies

Americans are not strangers to most of the elements of future communications systems. Telephone service has been widely available for decades. Most of us are more familiar with television than we ought to be. Computers, calculators, and copying machines are more recent innovations, but most of us have had considerable experience in using them. What will change most during the remainder of this century is how and where we use these familiar elements. Voice, video, text communications, computing, and computerized access to stored aural, visual, and text information are being permuted. One term proposed for the integrated, comprehensive communications service of the future is *compunications*. A French communications studies group has proposed another, *informatique*. Whichever—informatique rolls off my tongue easier than compunications—by the end of the century, integrated information utilities will provide ubiquitous, instantaneous access to much of the world's information at costs within reach of middle-class families.

One of the prerequisites to informatique is a highly sophisticated means of routing messages and information flows from any origin to any destination. Combinations of computer technology and new transmission techniques will do the job. Electronic (computerized) switching systems have been installed to serve many communities. Electronic switching systems are now being installed in the toll network as well. Computer-controlled switching makes several sophisticated services possible, such as call waiting, customer-arranged conference calls, and call following.

Conversion from electromechanical to electronic switching is especially appropriate in light of new transmission methods. Voice and video signals were traditionally transmitted as variable intensity electrical currents. Techniques are now available to sample sounds and visual images and transmit the sampled values (voice volume and pitch, visual hue and brightness) as a binary code. If the sound or image is sampled often, the coded samples can be used to reconstruct sounds and images at destinations. Binary or digital transmission is inherently better at squeezing information through a conducter of a given size. For that reason, all aural and control system communications in the Boeing 747 aircraft are transmitted in digital form. By using smaller conducters more efficiently, Boeing was able to reduce the aircraft's weight by several thousand pounds. Computerized switching of digital signals will be the major routing and transmission technique used in the next several decades.

A second prerequisite for achieving informatique is new transmission *media* through which to transmit digital signals. The most promising medium for accommodating future communications needs is laser transmission through optical glass fibers. The Bell System recently proposed to build an optical fiber link between Washington, D.C., and Boston, Massachusetts. When the cable is completed in 1983, it will carry 80,000 simultaneous telephone calls or the equivalent in data or visual communications. Existing microwave and coaxial cable links can carry maxima of about 18,000 and 32,000 simultaneous conversations, respectively. In addition to their bulk carrying capacity, small-strand optical fibers can be used to bring signals into individual homes and offices.

Historically, each important transmission innovation was hailed as offering almost unlimited capacity. Historically, each was shortly found to be inadequate for the demand it had itself created by sharply lowering transmission costs. It would be shortsighted to predict that transmission capacity constraints have been overcome. At the same time, the current and prospective development of microwave, coaxial cable, and fiber optics should provide adequate capacity at reasonable costs.

Satellites are the third key to making most kinds of information available in most places. Satellites can be installed quickly and cheaply, although they cannot match the larger capacity of optical transmission. The Washington-Boston optical cable, for example, will cost $79 million and take three years to build. A satellite can be built and placed in orbit in a matter of months for about $25 million. Space shuttle operations will sharply reduce the cost of putting satellites in orbit and recovering or repairing satellites that malfunction.

Satellites offer the additional possibility of direct broadcast to communications users. Satellites have heretofore been used as links between large earth stations. Signals have been transmitted between origin and earth station and earth station and destination by conventional terrestrial media. Direct linkages between satellites and individual home and office earth sta-

tions offer exciting possibilities for innovative communications services.

Satellite transmission will revolutionize communications pricing policies inasmuch as the cost of using satellites is independent of terrestrial distance. Traditionally, communications costs have been quite sensitive to terrestrial distance because of the expense of terrestrial facilities. If a satellite is used, the cost of sending a message across the street is the same as sending it across the continent.

Another geographical change that is in the works is freeing voice (and perhaps eventually, visual) communications from fixed-location terminals. Mobile telephones are rare and expensive because of radio frequency scarcities and high labor costs involved in establishing mobile radio interconnections. Telephone engineers have now devised techniques that reuse limited portions of the frequency spectrum over and over again in small geographical cells. Electronically controlled switching systems can find specified receivers, establish radio connections, and then automatically shift ongoing conversations from one radio frequency to another as mobile units travel from one cell to another. Experts in the field are confident that it will be possible, by the end of the century, to travel anywhere in the nation by any transportation medium without ever having to be out of telephone contact.

A combined set of services is now coming into the commercial market and providing a good indication of what will be commonplace in another decade or so.

Future office and home communications will focus on a cathode-ray screen similar to that found in a conventional television set. Ancillary computers will provide control of the information received, presented, and transmitted. Facsimile machines will provide hard copies of information displayed on the screen or received directly from near or distant storage. A variety of prototype text and data services for offices and homes now exists. Some use scrambled broadcast signals whereas others use wired transmission channels. Examples are Great Britain's Ceefax, Oracle, and Prestel; France's Antiope and Teletel; Germany's Bildschirmzeitung and Bildschirmtext; and Canada's Telidon and Vista, in addition to our domestic Info-Text.

How will these services be used? A share owner in a small town in South Dakota, for example, might query a data service in Chicago regarding the current price of his or her stock on the New York Stock Exchange. The videotext query and response would use the services of the general information utility that provides his or her home with telephone, television, computing, and electronic facsimile services. The same system could be used to keep household accounts, pay bills, and keep files on topics of interest to household members.

Business firms can use the same technology for their specific needs. The Johns-Manville Corporation recently began communicating among its several United States locations using its own earth stations and 144 voice and data channels it leases from RCA on the Satcom I and Satcom II satellites. The stations are located at the company's Denver headquarters, as well as in Chicago, New York, Atlanta, Houston, Los Angeles, and San Francisco. Services will soon be expanded to the equivalent of 600 voice circuits to provide television broadcast and conferencing capabilities.

Scientific-Atlanta is a firm that manufactures Homesat earth terminals. Telecommunications Incorporated is a Denver-based cable television network. The two recently signed an agreement for Tele-communications to lease Homesat stations to residential customers who live beyond the service area of Telecommunications' existing cable television network. Thus residents of sparsely populated areas where even cable television is not economically feasible will be able to receive television and other aural and visual services directly from satellites via their leased three-meter antennae. The use of individual earth stations beyond areas served by terrestrial lines is a logical extension of the technology that currently has over 1,600 earth stations in use by CATV networks for linkages among their conventional terrestrial networks.

Perhaps the most telling portent of the communications future throughout the nation appeared in the January 14, 1980, issue of *Telephony*. Sears, Roebuck & Company and the Communications Satellite Corporation (COMSAT) are negotiating a joint venture for providing direct broadcast of noncommercial television and other visual services from satellites to consumers. If the world's largest merchandising firm and the world's largest satellite communications company combine forces, surely the day of the electronic catalog is not far off.

Problems

There are some economic obstacles to widespread use of the communications technologies and arrangements described above, but they are surmountable. The unit costs of switching, transmission, and satellite capacity continue to drop. The major impediment to applying existing and forthcoming technologies will be the need to make satisfactory institutional arrangements among competing interests and the need to prevent technological abuse.

Telephone companies, the broadcast networks, cable television operators, COMSAT, Western Union, and communications equipment suppliers have varying stakes in existing regulatory arrangements. At the same time, all are playing for even higher stakes in the future, as are a host of firms trying to establish new services and develop new hardware. The total electronic communications market in 1980 will aggregate about $80 billion. Everyone involved is jockeying for position. Regulatory actions, appeals, and lawsuits are rife. The current state of regulatory affairs in electronic communications

The role of telecommunications in linking the places and peoples of the world is symbolized by this sculptured panorama that graces the front of the main telephone building in Los Angeles.

can most charitably be described as confusing.

The most important regulating agency is the Federal Communications Commission. The one consistent policy the FCC has adopted over the last decade is to promote competition and reduce regulation. Throwing the electronic communications industry open to comparatively free competition may resolve some confusion and make it possible to move more quickly from innovation to application, but recent history precludes optimism. Domestic satellite use and cellular mobile radio were delayed in application for a decade beyond the time at which each became technically and economically feasible. Similar regulatory and legal wrangling will have to be overcome before existing and future firms combine forces to create integrated information networks.

On the whole, planners and visionaries are too optimistic about the benefits of emerging technologies, and too prone to ignore negative effects or possible misuse. Only recently have security and privacy begun to receive much attention. Information stored, transmitted, and received in electronic form is inherently more subject to manipulation or theft than hard copy information. The electronic eavesdropping capabilities that have been developed for national security purposes are virtually omniscient. At the moment, the only sensible assumption regarding privacy is that any information that can be brought into the home or workplace electronically can be taken out in the same form, without the owner's permission or awareness. Experts in coding and scrambling are confident that secure channels and unbreakable codes can be devised that will preserve privacy and confidentiality. If they are wrong, one of the prices of advanced electronic communications may be greatly reduced privacy.

Prospects

Assuming these and other obstacles are overcome, how will these new means of moving and using information affect our daily lives?

Industries and facilities based on hard copies and hard-copy storage might decline. If most of the world's visual and aural information can be accessed digitally and electronically from almost any location, demand for libraries, theatres, filing cabinets, and conventional newspapers would stagnate. Two-way visual and audio communications and electronic fund transfer arrangements would reduce reliance on traditional media such as postal services. Anyone taking an extreme view might conclude that daily work and daily life in the future will be radically different from today.

The changes that will occur, however, will be more evolutionary than revolutionary. New technologies rarely replace older ways. Despite automobiles and airplanes, most of us still spend a lot of time walking. Similarly, there will continue to be a market for books and newspapers in the coming era of electronic communications. It will be a long time before curling up by the fire with a video screen is as appealing a prospect as curling up with a good book. We should exploit every opportunity to make good use of new information services, but it would be short-sighted to stop being concerned about libraries, publishing, and newspapers on the grounds that they are almost obsolete anyway. We will use new services to expand our total information processing capacity and to substitute for some of our current information processing procedures, but written and printed communications will continue to play important and valued roles for the purposes for which they remain most suitable.

Will electronic communications innovations have effects comparable to those of the railroads in the last two decades of the last century? It's difficult to say. There is much that is almost magical in what has been described here. A nation or a world in which information is equally available regardless of location, and in which costs of communication do not increase with distance, *is* geographical magic.

Our past use of transportation innovations such as the railroads and automobiles would suggest that a technology that made information ubiquitous and abundant would promote geographical dispersal. Each succeeding transportation or communication innovation seems to have promoted the scattering of facilities or the linking together of ever more distant facilities. Railroad transportation enabled Americans to settle a continent and bind it into a single nation. Streetcars (rail technology applied to local transportation) enabled people to disperse to suburbs and outlying communities.

What is often overlooked, however, is the degree to which previous technologies have simultaneously promoted concentration. Railroads made it possible to assemble the huge quantities of materials needed for the operation of great industrial units such as the Chicago-Gary steel complex. They made it possible to take the finished products from such units to national and international markets. Railroads solved the logistical problems of bringing in the foodstuffs and materials needed to supply the populations of metropolises such as Chicago and New York. At the same time that streetcars and subways were promoting outward expansion to suburbs, they were fostering unprecedented concentrations of business and commercial activities at the cores of the cities they served. The central city skyscraper complex is as much a monument to transportation and communications technology as the suburbs and exurban settlements that ring it. Neither is possible without efficient, low-cost transportation, and communications.

Communications technologies will no doubt have major impacts on the ways we work, play, and live in the future. Geographical rearrangements will be part of those changes. Americans have historically preferred dispersed living at low densities. An information-based economy

F. H. Beck to Receive '80 McFarland Award

Dr. Franklin H. Beck, professor of metallurgy at Ohio State University, will receive the 1980 David Ford McFarland Award of the Penn State Chapter of the American Society for Metals.

Dr. Franklin H. Beck '43, 1980 McFarland Award recipient.

The award will be presented at the chapter's annual dinner at Centre Hills Country Club, State College, Pa., Saturday, May 3, at 6:45 p.m. Reservations may be made with Dr. John H. Hoke, 221 Steidle Building, University Park, Pa. 16802.

Now in its 32nd year, this award recognizes outstanding achievement by a Penn State metallurgy alumnus and honors the memory of Dr. McFarland who was professor and head of the then Department of Metallurgy from 1920 to 1945.

Dr. Beck received his B.S. in metallurgy in 1943. For the next three years, he worked for duPont as a metallurgical engineer at various locations including the experimental station at Wilmington, Delaware, and the Manhattan Project at Richland, Washington. In 1946, he began graduate studies at Ohio State, receiving his M.S. in 1947 and his Ph.D. in 1949. He has remained at Ohio State as a member of the faculty since 1949, becoming professor of metallurgy in 1959.

He is recognized internationally as an authority on corrosion phenomena and corrosion-resistant materials.

and informatique offer opportunities for dispersal on unprecedented scales. But dispersal has historically been limited by the inertia of what has already been built, by time and cost constraints, and by the cultural attractions of high-density urban and metropolitan centers. Currently, energy shortages have emerged as a new constraint on dispersal. Informatique can conserve energy by making it possible to substitute communications for transportation. But the greater dispersal that might accompany such substitutions could use more energy than was saved. Commuting costs aside, low-density settlement is inherently less energy-efficient than high-density living.

At the moment, we can be confident that technology-induced change will occur, and that it will be more evolutionary than revolutionary because of forces of inertia. As perhaps at most times when people have attempted to assess the effects of technology on geography, we are in a poor position to specify with precision the changes in the nation's economic and social geography that will accompany new technologies.

(The current events and data reported in this article were taken from the January 14, 1980, issue of Telephony *and the January, 1980, issue of* Communications News.)

The Author

Dr. Ronald Abler has been with Penn State's Department of Geography since 1967. He teaches courses in cartography and communications geography. His research interests are postal and telephonic communications and their social and economic effects, urban geography, and cartography. He is the author of numerous articles on communications topics and editor of *A Comparative Atlas of America's Great Cities: Twenty Metropolitan Regions.*

Currently, he is engaged in research on the economic and social effects of postal and telephone services in Sweden and the United States between 1800 and 1975. The research is being conducted in collaboration with Dr. Thomas Falk, of the Stockholm School of Economics, who was a visiting professor in the Department of Geography in 1977-79.

1979-80 Scholarships in College Total $128,099

A total of $128,099 in scholarships has been granted to 180 students in the College of Earth and Mineral Sciences for the current academic year. This is the largest scholarship program of any college at Penn State.

More than 10 percent of the E&MS undergraduates received awards ranging in value from $50 to $2,000 in 1979-80.

Many of these scholarships are made possible by annual gifts from industries, foundations, and individuals, while others represent the annual income from endowment funds.

"In these times of increasing costs," points out Dr. C. L. Hosler, dean of the college, "more and more students need financial assistance and we are happy that our many donors make it possible for us to provide help for them.

"However," he continues, "there are still others that we would like to help so I invite any individual, organization, or company interested in establishing a scholarship to contact me." (The Dean's address is 116 Deike Bldg., University Park, Pa. 16802; (814) 865-6546.)

The single largest source of scholarships this year was the John and Elizabeth Holmes Teas Scholarship Fund. Thirty-four students received Teas Scholarships totaling $44,002. These were established in 1952 by L. P. Teas, a 1916 mining graduate, in memory of his parents. He died in 1970.

The second largest source of award money this year was the Edwin L. Drake

Four of the 20 high school students who spent several weeks last summer becoming acquainted with the field of polymer science in a special course at Penn State are shown here with the course director, Dr. Paul Painter, second from right, assistant professor of polymer science. The students, are left to right, Dean Chang and Boris Simkovich of State College, Pa.; Rina Banerjee of Little Neck, N.Y.; and Keith Judkins of Brooklyn, N.Y.

5-Week Summer Course Introduces Talented High School Students to Polymer Science

A five-week course, "An Introduction to Polymer Science," designed to acquaint talented high school students with polymer science as a scientific discipline, is being offered at Penn State, June 16 to July 18.

Director of the course, Dr. Paul Painter, assistant professor of polymer science, points out that the program is aimed primarily at students who have completed the junior year in high school. Its goal is to introduce them to the nature of polymer science and the opportunities in this field.

The first week of the program will be devoted to formal classroom instruction in the foundations of polymer science together with lab periods in which there will be demonstrations of and instruction in the application of analytical instruments to the study of polymers. In the remaining weeks, the students will undertake research projects involving the synthesis and characterization of polymers.

At the end of the course, Dr. Painter says, each student should have some idea of whether or not he would like to study polymer science on the college level.

The course was first offered last summer with an enrollment of 20 students from Pennsylvania, New York, New Jersey, and West Virginia.

Polymer science, Dr. Painter explains, is concerned with the study of large molecules of the kind that occur naturally in skin, wool, silk, and wood, and are produced synthetically to make a variety of materials such as polyesters, polystyrene, and nylon. Polymers find applications in many fields such as adhesives, textiles, and plastics. Polymer science, he notes, is a multidisciplined subject encompassing elements of all the traditional sciences such as chemistry, physics, mathematics, engineering, and the biosciences.

Further information about the summer course may be obtained from Dr. Painter, 325 Steidle Building, University Park, Pa. 16802; (814) 865-5972.

Memorial Scholarship Fund from which a total of $25,200 was awarded to 43 students. This program was set up in 1952 by John P. Herrick, publisher, oil producer, and philanthropist who died in 1961. It memorializes the man who drilled the world's first producing oil well at Titusville, Pa., in 1859.

Other scholarhip sources this year include: Alcoa Foundation, AMAX, American Olean Tile Co., American Ceramic Society, Amoco Production Foundation, William Bayer Memorial Scholarship Fund, Brockway Glass Co., Chevron Oil Co., Consolidation Coal Co., Consol-Sheridan Memorial Scholarship Fund, Continental Oil Co., Cooperative Program in Metallurgy Scholarships, Drakenfeld Division of Hercules, Inc., Earth & Mineral Sciences Alumni Scholarships, Ferro Corp., General Motors Scholarship Program, Getty Oil Co., Edward C. Hammond, Jr., Memorial Scholarship Fund, Harbison-Walker Charitable Fund, Heyl and Patterson, Oscar Hommel Memorial Scholarship, ICM Corp., International Nickel Co., Island Creek Coal Co., Lawrence County Ceramic Industries, Marathon Oil Co., North American Coal Co., Penn Grade Crude Oil Assoc., Penn State Metallurgy Alumni Scholarship Fund, Pennsylvania Drilling Co., Pennsylvania Ceramic Association, Pennzoil, Pittsburgh Plate Glass Industries, Quaker State Oil & Refining Co., Shell Oil Co., Sybron Community Fund, and Union Oil Co. of California.

Mining Engineering Graduate Students Needed to Fill Research Assistantships

Many opportunities to participate in a variety of challenging research projects related to the production of coal and other vital minerals are currently available to graduate students in mining engineering at Penn State.

"Right now, we have a number of positions for graduate assistants open on funded projects," reports Dr. L. A. Morley, associate professor of and graduate program officer for mining engineering. "These positions," he continues, "are normally filled by graduate students who use aspects of their work on the projects as the topics for their theses."

Substantial financial support is available for these students. Graduate assistantships pay from $2,300 to $6,500 or more depending on the student's qualifications, plus a grant-in-aid to cover tuition. Also some fellowships are available each year.

Dr. Morley invites anyone interested in knowing more about possible enrollment in the mining engineering graduate program to write to him at 119 Mineral Sciences Building, University Park, Pennsylvania 16802, or phone him at (814)863-1643.

"We have here at Penn State what we believe is the most comprehensive program of graduate work in mining engineering anywhere in this country," Dr. Morley says.

Three graduate degrees are offered—master of engineering, master of science, nd doctor of philosophy.

The master of engineering is a professionally oriented degree that requires 30 course credits and a scholarly written report on a study pertinent to the discipline. Devoting full time to his or her studies, a student can complete this program within three to four 10-week terms.

The master of science degree requires 24 course credits and six research credits plus the presentation of a thesis written out of a research project. The typical student can complete this program in 18 to 24 months.

The Ph.D. program is research-oriented and has an M.S. degree as a prerequisite. It requires a minimum of 90 credits—30 of these may be allowed from the M.S. degree—plus the presentation of a thesis on an original research project. The typical student takes 24 months to complete this program.

Candidates for the M.S. or Ph.D. may elect the dual-title degree program in operations research. This provides them a solid background in the tools, techniques, and methodology of operations research which involves the analysis—usually the mathematical treatment—of a process, problem, or operation to determine its purpose and effectiveness to gain maximum efficiency.

An interdisciplinary program leading to the master of engineering degree in mineral engineering management is also administered in the mining section of the Department of Mineral Engineering. It emphasizes quantitative methods, principles of economics applied to mineral industries, and management. The administrative units that combine their resources to offer this program are three departments in the College of Earth and Mineral Sciences—Mineral Engineering (mining engineering, mineral processing, and petroleum and natural gas engineering sections), Materials Science and Engineering (fuel science, metallurgy, and ceramic science and engineering), and Mineral Economics; and the Department of Industrial and Management Systems Engineering in the College of Engineering. Many mineral-related companies, which—faced with a shortage of mineral engineers—are hiring graduates of other engineering majors, find this type of training particularly valuable.

Not only students with degrees in mining engineering, but also those who have degrees in areas related to mineral engineering such as geology or geophysics, or in engineering areas such as civil, mechanical, electrical, aerospace, chemical, or industrial are encouraged to apply for admission to the mining engineering graduate programs.

The course programs may be tailored to fit the individual's needs and interests within the framework of the general requirements. Graduate assistants, in addi-

A major research area in mining engineering at Penn State in which graduate students may become involved is mine electrical systems and components. In the mine electrical research laboratory, the cart-like apparatus shown here is run back and forth to put wear and tear on the electrical cable that is wound around the vertically mounted wheels in the foreground and the horizontally mounted wheel on the rear of the cart. The object is to test the durability of splices made in the cable which is the type used to supply power to underground mining machines. Working with the cart are, left to right, George Luxbacher and Thomas Rusnak, research assistants, and Abel Folarin, a graduate student.

tion to working on research projects, may be asked to assist in teaching by conducting undergraduate laboratories and grading exams, problems, and laboratory reports.

Penn State, Dr. Morley points out, is among the leading universities in the U.S. conducting mining engineering research, and it has granted more Ph.D. degrees in this area of study than all the rest of the institutions combined. Penn State mining alumni, he says, fill important faculty positions at most of the universities that teach mining engineering, and also hold positions of leadership in many mining companies throughout the U.S.

He lists the following areas in which one or more of the faculty members have expertise:

—Mine systems, design, and planning, both surface and underground.
—Production engineering—mostly computer applications, including but not limited to operations research.
—Management.
—Geomechanics—all aspects including classical rock mechanics.
—Ventilation.
—Mine electrical systems—and electrical engineering applications in mining.
—Innovative mining machinery and systems.
—Methane drainage prior to mining.
—Environmental aspects of mining.
—Mine drainage.

The research facilities available to mining engineering graduate students at Penn State are among the very finest in the nation, Dr. Morley points out. These include laboratories for mine electrical research, ventilation studies, and sophisticated work in rock mechanics. Also, researchers have access to an IBM 370/3033 computer, with several remote job-entry terminals located in the mining section.

"However, actually, our main laboratories are the mines of the many companies that cooperate with us in our research efforts," Dr. Morley says, noting that these range from Pennsylvania coal mines to open-pit copper and molybdenum mines in the western U.S.

College News Notes

Edits Ore Deposits Book

Dr. H. L. Barnes, professor of geochemistry and director of the ore deposits research section in the College of Earth and Mineral Sciences, is the editor of a new book, *Geochemistry of Hydrothermal Ore Deposits,* a comprehensive, state-of-the-art review of the processes by which ore deposits are formed by the action of hot aqueous fluids.

This is the second edition of the book. Published by Wiley-Interscience, it has been entirely rewritten and incorporates the major advances in the understanding of the ore-forming processes that have been developed in the decade since the first edition was published. The first edition was also edited by Dr. Barnes.

Five faculty members, including Dr. Barnes, one former faculty member, and a Penn State geosciences alumnus are authors or co-authors of seven of the 15 chapters in the book.

These authors and their chapter titles are: Dr. Barnes, "Solubilities of Ore Minerals"; Dr. C. Wayne Burnham, professor of geochemistry and head of the Department of Geosciences, "Magmas and Hydrothermal Fluids"; Dr. A. W. Rose, professor of geochemistry, with Dr. Donald M. Burt, of Arizona State University, "Hydrothermal Alteration"; Dr. Hiroshi Ohmoto, professor of geochemistry, with Robert O. Rye, of the U.S. Geological Survey, "Isotopes of Sulfur and Carbon."

Dr. L. M. Cathles, associate professor of geosciences, with Dr. Denis Norton, of the University of Arizona, "Thermal Aspects of Ore Deposition"; Dr. Hugh P. Taylor, Jr., a member of the Penn State geochemistry faculty in 1961-62, now at the California Institute of Technology, "Oxygen and Hydrogen Isotope Relationships in Hydrothermal Mineral Deposits"; and Dr. Paul B. Barton, Jr., who received his B.S. in geosciences from Penn State in 1952 and is now with the U.S. Geological Survey, with Dr. Brian J. Skinner, of Yale University, "Sulfide Mineral Stabilities."

Rose Edits Revised Second Edition

Dr. A. W. Rose, professor of geochemistry at the University, is co-author of *Geochemistry in Mineral Exploration,* second edition, just published by Academic Press, London.

Co-authors with him are Herbert E. Hawkes, a consultant in Tucson, Arizona, and John S. Webb, professor of applied geochemistry at the Imperial College of Science and Technology in London, England.

Since many advances have occurred in the geochemistry of mineral exploration since the first edition of the book was published in 1962, the original text has been extensively revised and updated.

Like the first edition, the second edition is addressed to four principal groups of readers: (1) students, as an introductory textbook; (2) exploration geochemists as a source book and reference to the literature; (3) specialized research workers in allied fields; and (4) nonspecialized earth scientists who want a source of general information on exploration geochemistry.

A member of the University faculty since 1967, Dr. Rose also serves as director of the Mineral Conservation Section in the College of Earth and Mineral Sciences. He is currently serving as vice president of the Association of Exploration Geochemists, an international organization.

Eggler Receives Volcanology Award

Dr. David H. Eggler, associate professor of petrology, has received the 1979 L. R. Wager Prize in Volcanology of the International Association of Volcanology and Chemistry of the Earth's Interior.

Presentation of the award, which commemorates the work of the late Professor L. R. Wager, head of the department of geology and mineralogy at the University of Oxford in England, was made last December at the quadrennial meeting of the International Union of Geodesy and Geophysics in Canberra, Australia.

The prize is awarded to scientists under 40 in recognition of outstanding contributions to the studies of volcanic rocks, particularly those made in the eight-year period preceding the meeting at which the award is made. This is only the second time it has been presented. The recipient is selected by a subcommittee on volcanology of the Royal Society of Great Britain.

Dr. Eggler's research has consisted primarily of experimental studies connected with the eruption of lavas on the surface of the earth and also the origin of the magmas from which these lavas are derived.

Cahir Receives Award

Dr. John J. Cahir, associate professor of meteorology, has received the 1979 Award for Outstanding Contributions to Applied Meteorology made annually by the National Weather Association to a member of a university faculty.

The award, which was presented at the Association's annual meeting held recently in Denver, Colorado, recognizes Dr. Cahir's research in the use of the minicomputer in weather forecasting.

He has been the leader of a team of researchers that includes Dr. Gregory S. Forbes, assistant professor of meteorology, and Walter D. Lottes, research assistant in meteorology, both at the University; Dr. John M. Norman, former University faculty member now professor of agronomy at the University of Nebraska; and Capt. Timothy Crum, USAF, who received both a B.S. and M.S. in meteorology from Penn State, and is now at Langley AFB, Virginia.

This group has been developing and testing techniques for rapid analysis and forecasting of the weather. Systems that will make these approaches possible are currently being deployed in weather stations throughout the country. Emphasis in the work has been on short-term prediction of weather features of intermediate

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.

Elements of Coal Preparation, May 12-14.

Principles and Practices of Mine Ventilation, May 12-16.

Theory and Practice of Coal Petrology, June 2-4.

Underground Mining Analysis, June 2-6.

Production Engineering in Underground Coal Mines, June 9-11.

Elements of Underground Coal Mining, June 16-18.

Computer Simulation Model for Underground Coal Mine Planning, June 16-18.

Computer Simulation Model for Surface Mining, June 18-20.

Mining Professional Engineering Exam Review, July 7-11.

Coal Cutting Technology, July 14-16.

size such as bands of clouds and showers along atmospheric fronts and jet streams.

The work has been supported by the Systems Development Office of the National Weather Service which is a part of the U.S. Department of Commerce.

Receives Most Minerals Fellowships

Penn State received the largest number of fellowships of all the 51 colleges and universities that were awarded support for graduate students for 1979-80 under the Domestic Mining and Mineral Fuel Conservation program that is authorized under Title IX, Part D of the Amended Higher Education Act of 1965.

The U.S. Officer of Education awarded $4.5 million to support a total of 464 graduate students. Penn State's share was $413,400 for 40 fellowships, all which were awarded to graduate students in the College of Earth and Mineral Sciences. Other institutions receiving the largest amounts were Colorado School of Mines, $330,200, for 36 fellowships; University of California at Berkeley, $203,450 for 30 fellowships; University of Arizona, $314,600 for 29 fellowships; University of Utah, $285,350 for 29 fellowships; and University of Idaho, $209,300 for 27 fellowships.

Carbon Formation Studies Funded

A grant of $134,990 from the U.S. Department of Energy to support studies of carbon formation rates and mechanisms over a two-year period was received recently by Dr. Howard B. Palmer, professor of energy science and associate dean of Penn State's Graduate School, and Dr. James J. Reuther, assistant professor of fuel science.

Objective of the research is to contribute to the solving of the problem of soot formation in the hydrocarbon-reforming systems used, or proposed for use, in the preparation of gaseous fuel for the fuel cells being developed for application to large-scale power production. The work is being done in the Fuels and Combustion Laboratory of the Fuel Science Section of the Department of Materials Science and Engineering.

Take Part in Palynology Program

Dr. Alfred Traverse, professor of palynology, and seven College of Earth and Mineral Science alumni were among the participants in the 12th annual meeting of the American Association of Stratigraphic Palynologists in Dallas, Texas, last fall.

Dr. Traverse, who was a co-founder of the association, presided over a technical session and was co-author of two of the papers presented.

Coal Research Booklet Available

Coal Research/Penn State is the title of a handsome and informative new booklet just issued by the University's Office of the Vice President for Research.

About two-thirds of the research described in the publication is being done by faculty members of the College of Earth and Mineral Sciences. Requests for copies may be sent to the editor, Harlan Berger, 207 Old Main, University Park, PA 16802.

Members of the committee of undergraduates planning EMEX 80, the biennial open house in the College of Earth and Mineral Sciences to be held April 12 and 13, are shown examining a quartz crystal, one of the many minerals exhibited in the college's Earth and Mineral Sciences Museum. Left to right are: Julianne Turko, 8th term geosciences major, who is EMEX general chairman; Dave Plummer, 5th term meteorology major; Robin Busch and Robin Clodgu, both 8th term earth sciences majors; and Mike Weber, 5th term geosciences major.

College Open House to Be Held April 12-13

Some of the finest University facilities in the country for meterological, mining engineering, coal, geological sciences, and materials research will be opened to the public for EMEX 80, the biennial open house in the College of Earth and Mineral Sciences, sponsored by the E&MS Student Council with the cooperation and help of faculty members.

Several thousand visitors are expected to tour laboratories and see a variety of exhibits and demonstrations in the college's four buildings — Steidle, Mineral Sciences, Deike, and Walker — from 1 to 5 p.m., Saturday and Sunday, April 12 and 13.

Among the highlights of the program will be tours of the meteorological observatory, the mine electrical research laboratory, the mine ventilation laboratory, seismological facilities, and metallurgy and other materials research laboratories. Demonstrations will include the college's scientific glassblower, John Daly, at work; gem cutting and polishing; computerized mapmaking in the Department of Geography; and radar and other weather data-gathering facilities.

The alumni participants, all authors or co-authors of papers, were: Peter K. H. Groth, B.S., 1964 and M.S., 1966; Francis T. C. Ting, Ph.D., 1967; Frederick J. Rich, Ph.D., 1979; Deborah Delfel, M.S., 1979; Bruce Cornet, Ph.D., 1977; Daniel Habib, Ph.D., 1965; and Robert E. Strother, Ph.D., 1972.

Organizes Strata Control Committee

Dr. Z. T. Bieniawski, professor of mineral engineering, was recently appointed chairman of a newly established committee of the Underground Technology Research Council (UTRC).

The committee, which is being organized by Dr. Bieniawski, is concerned with strata control engineering in both coal and hardrock mining. Its members come from all over the U.S., representing industry, consulting engineering firms, government, and universities.

The UTRC is sponsored jointly by the American Society of Civil Engineers (ASCE) and the American Institute of Mining, Metallurgical, and Petroleum Engineers.

Dr. Bieniawski was also recently named a member of the committee on rock mechanics of the geotechnical division of the ASCE.

Last fall, he served as one of four invited main session chairmen for the 4th International Congress on Rock Mechanics in Montreux, Switzerland. Other session chairmen came from Italy, Portugal, and Austria. The congress, held every five years, is the main scientific event organized by the International Society for Rock Mechanics. Dr. Bieniawski is a past vice president of the society, and, at this meeting, was elected a co-president of its commission on testing methods.

Participates in Symposiums

Dr. Richard L. Gordon, professor of mineral economics, recently participated in two U.S. government symposiums and also has been elected an editor of two journals.

He served as a discussant in a Department of Energy symposium on coal resources/reserves information, and was one of six panelists for a Library of Congress briefing on coal problems.

He has been appointed to the editorial boards of "Resources and Energy" and "Energy Journal," the journal of the International Association of Energy Economists. He is also now a member of this organization's executive council.