mines magazine

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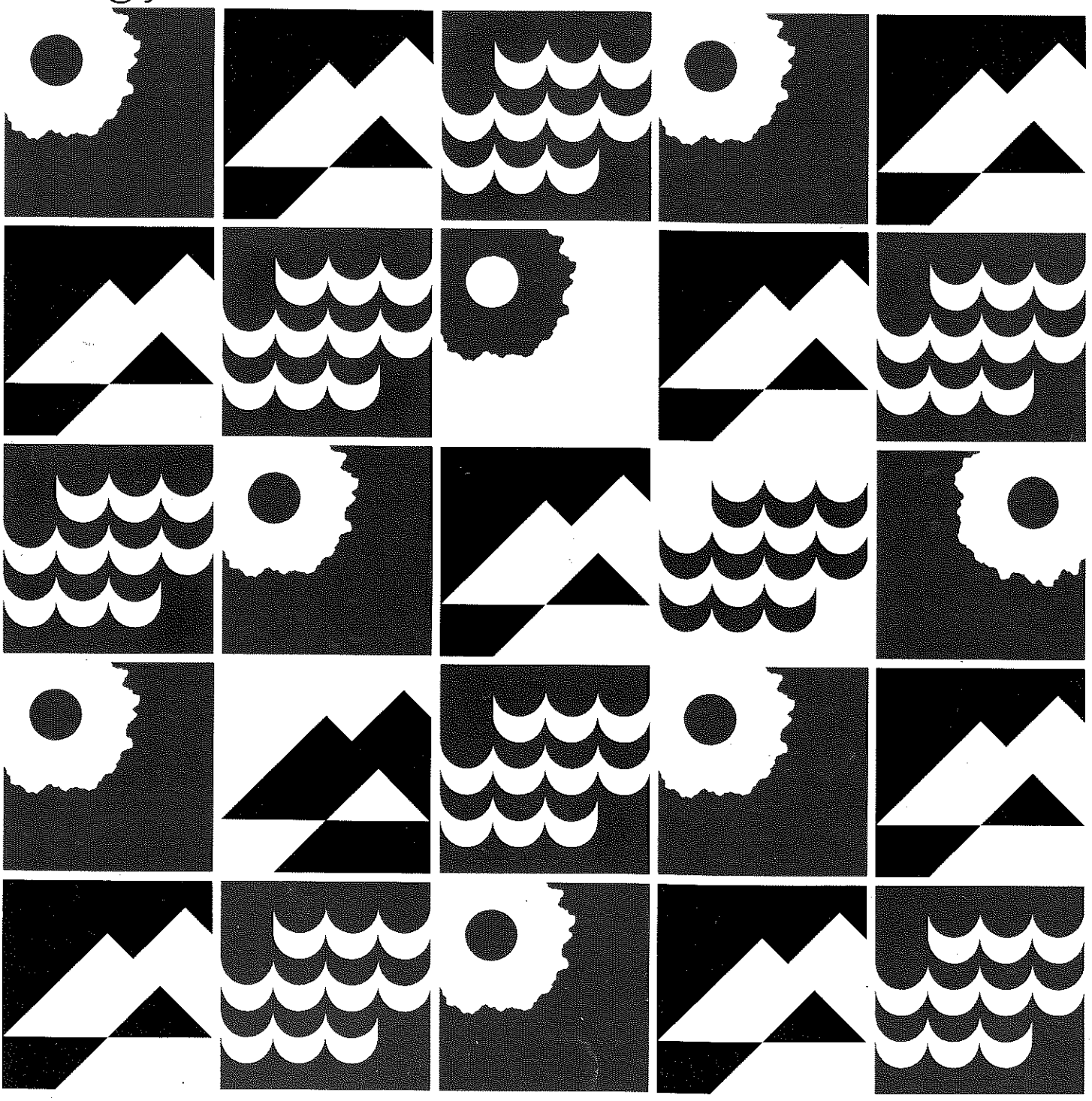
Energy Alternatives



alumni events calendar

Feb. 8—CSMAA Luncheon at CMA Convention, DAC, 11:30 a.m.
Feb. 9—Alumni Day College, Green Center, CSM Campus—"More For Your Management Dollar". Contact CSMAA office.
Feb. 9—FOUNDER'S DAY BANQUET, Holiday Inn West, 6:30 p.m.
Feb. 26-28—Cont. Ed. "Maintenance Management for the Mining Industry," Denver, CO. For further information contact K. M. Barbour, CSMAA.
Feb. 27—CSM Breakfast at AIME National Meeting, Las Vegas Hilton, Las Vegas, 7:30 a.m.
March 11-13—Cont. Ed. "Coal Industry Review". Denver, CO. For further information contact K. M. Barbour, CSMAA.
March 18-20—Cont. Ed. "Maintenance Management for the Mining Industry," Denver, CO. For further information contact K. M. Barbour, CSMAA.
April 8-10—Cont. Ed. "Maintenance Management for the Mining Industry," Keystone, CO. For further information contact K. M. Barbour, CSMAA.
April 11-12—E-Day
May 8-10—COMMENCEMENT PROGRAM
8—Reunions for 1925, 30, 35, 40, 45, 50 & 55
9—Commencement Banquet, Green Center, 6:30 p.m.
10—COMMENCEMENT
June 3-5—Cont. Ed. "Maintenance Management Seminar for the Mining Industry," Keystone, CO. For further information contact K. M. Barbour, CSMAA.
July 29-31—Cont. Ed. "Coal Industry Review", Denver, CO. For further information contact K. M. Barber, CSMAA.

mines magazine

volume 70 **february, 1980** **number 2**

features

departments

Official organ of and copyrighted, 1980, by the Colorado School of Mines Alumni Association. Second Class postage paid at Golden and Denver, Colorado. Subscription price: regular CSMAA members and non-alumni subscribers, $10.00 per year, CSMAA junior members, $3.50 per year, United States and possessions. Foreign subscribers, $12.50. Single copies $1.00, except special editions. Published monthly except July. Annual Directory, MINES Magazine, issued August. The publisher reserves the right to determine content of advertising carried in the magazine. All correspondence should be directed to: CSM Alumni Association, Colorado School of Mines, Guggenheim Hall, Golden, CO 80401. Publication #ISS N 0098-4859

comments . . .

What's More Valuable Than Gold?

by Marshall C. Crouch III, '67

As the Alumni Association enters a new year, it's time to recognize those whose work saw your Association through 1979. Your Association is designed to be a volunteer organizaiton which has a paid staff to coordinate the volunteer efforts and to run the day to day operation of the outfit. The members of the Association are represented by an elected Board of Directors which included last year: Robert Brace, '49, President; Marshall Crouch, '67, Vice-president; Thomas Smagala, '74, Treasurer; Richard Daniele, '60, Secretary; and Board Members: John Beers, '53; Niles Grosvenor, '50; John Lockridge, '52; Robert Reeder, '49; and Steve Mooney, '56. Directors of the CSM Foundation, Inc. were Art Meyer, '50; and Donald Craig, '48. James Link, '59 sat on the several Foundation committees.

The Board met at least monthly and often more frequently from February through June and August through January. The regular Board meetings, which are open to all alumni, are held on an evening in the second or third week of the month in Guggenheim Hall. Exact time, date and agenda may be obtained from the Association office or any Board member. All are welcome to attend and participate in your Association business.

The Association finished the year with an operating loss of $6100. Operating income was $213,300 against expenses of $219,400. Non operating income was $9100 and consisted of donations from alumni to the Association's Loan, Operating and Trust Funds. The *Finance Committee*, which was made up of Thomas Smagala, '74, Chairman; Richard Daniele, '60; Richard Angerer, '59; David Scriven, '70; Stewart Squires, '74; and Dunn Krahl, '54, reviewed the Association budget, monitored actual income and expenses and made Trust Fund investment recommendations. A more complete financial statement will be made to you in the *MINES Magazine* by the Treasurer after the annual audit has been completed.

More alumni paid dues to the Association in 1979 than ever before. Out of 8700 known, living alumni, 3959 or 45.5% were members. The increase over 1978 of 364 new members was registered by the hard working *Membership Committee* which had as co-chairmen Gary Nydegger, '74, and Steward Squires, '74, and as members Betty Decker, Hon. '78; Paul Dorr, '74; Andrew Pfaff, '74; Claude Fertig, '27; James Ogg, '52; Bud Vaseen, '39; and John Lindemann, '64.

Approximately 30 loans totaling over $25,000 were made to needy students by the *Loan Committee* composed of John Wright, '69, Chairman, and members W. Richard Moore, '66 and Warren Mason, '43. Your donations to this valuable Alumni activity will insure continued financial support for students who might not be able to graduate without an Alumni Association loan.

The *MINES Magazine* was published monthly except during the months of July and August, and the *Directory* was mailed to all of you in August. Articles to the magazine were contributed by a large number of people including alumni: Robert Brace, '49; Clark Davenport, '64; Phillip Ehr, '59; Thomas Ise, '55; Gerald Jergensen, '65; Robert Kane, '54; Harry Kent, '52' Guy McBride, Hon. '72; Charles McNiel, '71; Terry McNulty, '67; Albert Schlechten, Hon. '67; Steve Schwoclow, '70; Bud Vaseen, '39; and George Vranesh, '51. George Mitchell, '53, Publisher, and Patricia Petty, Editor, contributed more than their fair share. We are especially grateful to Leanne Gibson, CSM Public Information Officer, for her numerous, timely and interesting articles about school and campus activies. To all who contributed to the *MINES Magazine* last year a hearty thanks. Out of 4,000 members of the Association, there must be more budding authors. How about an article this year! Patricia Petty was advised by a *Publications Committee* of George Vranesh, '51; Richard Doran, '64; and Gene Woolsey, Assoc. '79.

The *Magazine & Directory* would be impossible without the financial backing of the advertisers. Many alumni support the Association by either buying ads themselves or by having their firms advertise. Thanks for your support last year and in years past. Without your advertisements, the *Magazine* and *Directory* would be a shadow of the present publications.

Each year three or more individuals have been recognized by their fellows for their outstanding service to alumni and the school by an Honorary Membership in the Alumni Association. Those so honored last year were Lindy Barker, '31; David Cole, '52; Edwin Crabtree, '27; and Charles Fogarty, '42. Their nominations were made by the *Honorary Membership Committee* consisting of Francis Smiley, '40, Chairman; Ed Brook, '23; William Leckie, '73; Walter Dumke, '29; and the late Neal Harr, '54.

A new committee of the Association has been charged with the responsibility of working with the *Local Sections*. John Lindemann, '64, past president of the Denver Section is Chairman and Rod Eichler, '71, past president of the Houston Section, is helping out.

The annual election for Association officers which was just concluded had a fine slate of candidates selected by the *Nominating Committee* of Donald Craig, '48; James Link, '59; and Art Meyer, '50. The task of counting over 2,000 ballots fell to the *Teller Committee* of Walter Dumke, '29 and Francis Smiley, '40.

Each of us who attended a meeting sponsored by a Local Section last year is grateful to those Local Section officers and volunteers who gave freely of their time so we could enjoy a Mines get together.

The list of those who helped the Association during 1979 will be complete with recognition of the diligent Association Staff. Although the buck stops on George Mitchell's ('53) desk, he relied heavily last year on Betty Decker, Hon. '78, who handled Local Section support, membership, student programs, meetings and reunions; on Patricia Petty, Director of Publications; on Kathy Barbour, Continuing Education Course Coordinator; and on Sharlet Berensten, Placement Director. Jayne Bowman saw that alumni records were kept straight, while Joan Barwin labored with the AADF program. Sue Strode handled various and sundry aspects of the publications business.

A lot of people made the Association work last year. Thank you all!

—mm—

Geothermal Energy

by Dr. George V. Keller

At half a dozen places around the world, steam produced from holes drilled deep into the earth is used to spin turbines that generate electric power. At Lardarello, in the Tuscany Hills of Italy, electric power has been generated from geothermal steam for a half century, and at present, plants in the vicinity of Lardarello and Monte Amiato have a capacity of about 500 megawatts. Near lake Taupo, on the North Island of New Zealand, geothermal steam has been used for nearly 20 years to supply a generator station with a capacity of about 190 megawatts. In 1973, the Republic of Mexico brought on line a modern geothermal generating plant with the capacity of 60 megawatts, located near an insignificant volcano named Cerro Prieto. At half a dozen other locations around the world, heat energy from the earth is being used to provide inexpensive electrical power for local communities.

The geothermal industry has also had a relatively long history in the United States, with the first production of electricity having been undertaken at the Geysers Resort, north of San Francisco in the Myacmas Mountains, in the 1920's. This early generation was fed with steam produced from shallow boreholes and amounted to only a few kilowatts of capacity, but in the last decade, it has been realized that this Geysers geothermal field may be the world's largest. The generating capacity of operating plants at the Geysers is about 500 megawatts, with other plants under construction or in design to double the capacity within a few years. To place the scale of geothermal energy in proper perspective, one must compare the projected capacity of the Geysers field, which will be about 1000 megawatts, with the nation-wide demand for electricity, which is currently more than 400,000 megawatts. Geothermal sources currently provide less than a quarter of one percent of our generating capacity.

While the Geysers field is the only operating geothermal field in the United States, exploration over the past few years has been successful in delineating several other fields which are capable of being developed for the generation of electric power at competitive prices. In the past two years, some 30 deep test wells—wildcats—have been drilled in the western United States in the search for new, previously unrecognized geothermal reservoirs. Some of these, such as the test wells drilled at Chandler, Arizona, at Brady's Hot Springs in Nevada, at Mountain Home and in the Raft River Valley in Idaho, and at East Mesa in southern California, have encountered high temperatures at shallow enough depth to indicate some potential for development, but definition of the size of the potential has not yet been made. Even more preliminary work, consisting of geological and geophysical studies, has been carried out over several hundred potential prospects.

Among its advocates, the promise for rapid expansion of geothermal power generation is bright, but for others, it is difficult to see how an industry which is so small at present can expand rapidly enough to have a significant impact on the power industry within time to contribute to the solution of our current problems in energy delivery. This dichotomy of viewpoint has led to a number of conflicting projections of the size of the geothermal industry at the end of this century, ranging from the most pessimistic, which sees no real increase in present geothermal generating capacity, so that the geothermal share of the market will actually decline to less than 0.1%, to the most optimistic, which forecasts a growth to 395,000 megawatts of geothermal generating capacity by 1999, or about 40% of the electric power market in the United States at that time.

What is the future, then, for geothermal energy, and how will its development relate to the development of other diversified energy sources, such as nuclear, solar and solid fossil fuel energy sources?

What is Geothermal Energy?

Geothermal energy is the heat energy contained within the solid earth and flowing continuously from it. Many measurements made around the earth have shown that the average heat flow is 1.5 microcalories per square centimeter per second. This quantity of heat is quite small, less than 1 percent of the heat received at the surface of the earth from the sun. It is not insignificant, however, inasmuch as the electrical equivalent of this heat flow rate amounts to 120 kilowatts per square mile. With a population density of 60 people per square mile, this means that the geothermal heat flow amounts to 2 kilowatts per person in the United States, which, by a striking coincidence, is precisely the demand for electric power in the United States today.

Physically, it is quite impractical to collect all of the natural heat flow from the earth and convert it to electricity with 100 percent efficiency. It is clear then, that natural heat flow from the interior of the earth is not a significant energy source. Because the earth is an extremely poor conductor of heat, much heat is stored within its depths. Let us consider the potential for using stored heat as an energy source. Temperature generally increases with depth in the earth. The average rate of increase in the United States is 1.6°F per hundred feet of depth, or 27°C per kilometer. Rock which lies at a depth of 2 to 3 miles below the surface, depths which can be reached by the drill bit quite readily, have an average temperature at these depths of 280°F (137°C). The heat capacity of rock—its capacity for storing energy—is almost exactly 1 calorie per cubic centimeter, for each degree Centigrade of temperature. If we remove the heat from a cubic mile of rock, so that its temperature is reduced

from 280°F to 100°F, the amount of heat obtained is very great, amounting to 4.4 x 10^{17} calories/cubic mile.

The laws of thermodynamics make it impossible to convert all this heat energy to electrical energy. If a machine were made to operate with 100% mechanical efficiency, still only 32 percent of this heat could be converted to electricity. Assuming that a generator has some mechanical inefficiencies, we would probably be able to convert only about 20 percent of the heat energy to useful electrical energy. The amount of electrical energy obtained from each cubic mile would be 1.02 x 10^{14} watt hrs. At our present rate of usage of electric power—400,000 megawatts, this energy would last for 11 days. Considering the entire land area of the United States, there is sufficient energy recoverable from rocks at depths between two and three miles to meet our present electrical demands for a period of 109,000 years.

This calculation is probably as unrealistic in detail as was the one concerning steady state heat flow. However, it indicates that the resource base—that is, the total amount of stored heat energy on which we may draw—is dramatically large compared to anything we may actually do. In this case, it is physically possible to recover the amount of energy indicated, but we may be unwilling to pay the price.

At the present time, we cannot produce electricity from geothermal heat competitively with other energy sources unless we have a very high-grade concentration of energy, in a form commonly called a "geothermal reservoir." The characteristics of these geothermal reservoirs are rather poorly known, and this is the primary cause for the uncertainty about the potential for the occurrence of economically viable geothermal systems.

Workers in the field speculate that there are four essentially different types of high grade geothermal reservoirs that may be exploitable; the hyperthermal sytems, the geopressured systems, the molten rock systems, and the high heat flow or hot, dry rock systems.

Hyperthermal Systems

The geothermal systems which are being used around the world today have extremely high temperatures, in the range from 500° to 600°F, at relatively shallow depths, and are called hyperthermal systems. All occur in rocks with a high water content, from 10 to 30 percent by volume. This water serves as a heat exchange medium which flows freely into boreholes and carries the heat to the surface and to turbines with few technical difficulties. The pressure of the overlying rocks and water keeps the water in the reservoir in the liquid state, even when the temperature is far above the atmospheric boiling point. The waters may boil in the reservoir, however, and enter the borehole as steam under pressure, as occurs at the Geysers and Lardarello, or it may enter the borehole as a boiling mixture of water and steam, as at Wairaki in New Zealand and at Cerro Prieto, in Mexico. In the latter case, the water must be separated from the steam at the surface and disposal arranged.

Most researchers believe that heat source for a hyperthermal system is molten rock which has been intruded to shallow depths in the earth's crust. Many of the known hyperthermal systems occur along belts of volcanic activity, as in New Zealand, the Phillipines, Japan, El Salvador, and Chile. Other major fields, such as the Geysers and Lardarello, do not occur in this close association. It might by hypothesized that these fields lie over major reservoirs of molten rock in the earth's crust, but evidence is weak. Another possibility in these areas is that water-laden rocks, such as shale, have been thrust deep into the earth by faulting and folding, and that heat has driven water or steam back to surface rocks along permeable channels. In either case, large quantities of heat have been transported to shallow depths by mass transport. Thus bypassing the thermally insulating properties of rocks in general.

Geopressured Systems

Another type of geothermal reservoir may occur in areas where sediments are being deposited rapidly, as along the Gulf Coast of the U.S. Normally in areas of less than rapid sedimentation, rocks become lithified and support the weight of overlying sediments without undue compaction. In such a sequence, one may measure the pressure of the fluids in pore spaces of the rock and find that it is the same as though one had an open column of water; that is, the pressure on the water in the rocks is only hydrostatic. In rapidly sedimenting systems, the rock may not become lithified rapidly enough to support the pressure from above. The rock at depth is then compressed, at the expense of pore space. In order to reduce pore space, water must be forced out of the rock, and this results in a pore pressure greater than hydrostatic. In extremes, the pressure on the pore water at depth represents the weight of both the overlying water and solids, so that the pressure amounts to 2.0 to 2.2 times the hydrostatic pressure. Such rocks are said to be "geopressured." If a hole is drilled into a permeable zone in a geopressured section, great volumes of water will flow to the surface. This is often catastrophic when an oil well is drilled into a geopressured zone unexpectedly.

A geopressured zone can be considered a geothermal system if it lies at 15,000 to 20,000 feet depth, where the temperature is 300° to 400°F even without abnormally high heat flow being present. Electric power can be generated both by letting some of the water flash to steam to operate a turbine, and by using the excess pressure of the flowing water to turn a water wheel. The cost of drilling to develop geopressured systems seems to be the only hindrance to developing such systems.

Molten Rock Systems

Some researchers feel that molten rock would be the ideal source of geothermal energy, in view of its high heat content and high temperature. Cooling a mass of molten rock from a temperature of several thousand degrees F to 100°F would produce about ten times the heat calculated for normal heat flow, and because of the higher temperature, the efficiency of converting heat to electricity could be improved significantly. A cubic mile of molten rock could supply electrical energy to the entire United Ustates for a period of about 200 days. The extent of our resources of molten rock is poorly known, with the lava lakes at Kilauea Volcano in Hawaii the only known occurrences of molten rock in the United States. Volcanologists estimate that the annual production of newly molten rock in the crust over the whole earth is only two cubic miles, which is not an impressive quantity in terms of electrical power production. The technology required for handling molden rock may not be easily available, and it appears unlikely that molten rock is a significant source of geothermal energy for the near future.

Hot, Dry Rock Systems

The average temperature gradient in the United States is 1.6°F per hundred feet. The gradient is less in some areas and more in other areas. These values of gradient might be thought of as representing some statistical distribution with a median value and a standard deviation. Temperature measurements compiled for hundreds of thousands of oil wells suggest the standard deviation is ±30% of the median value. This would mean that over one-third of the area of the United States, the temperature gradient is more than 2.1°F per 100 feet, over 8 percent of the country, the gradient is greater than 2.7°F per 100 feet, over 2 percent of the country the gradient is greater than 3.5°F per 100 feet, and over 1% of the country, the gradient is more than 4.6°F per 100 feet. This last one percent of area, which amounts to 36,000 square miles, could be considered to be a hot, dry rock resource, in that the temperature at 10,000 feet depth would be above 530°F. The recoverable heat and electricity that could be obtained would be 3 to 4 times greater than in the case of average heat flow, and the cost per unit would be lower by the same factor.

One approach to recovery of heat from such rocks would be to drill two holes, and circulate a heat exchange fluid from one well to the other to extract the heat. In order to have efficient heat exchange between the rock and the fluid, a large contact area must be provided. Research is currently being carried on by the Los Alamos Scientific Laboratory to develop techniques for creating a large planar fracture, perhaps a mile in diameter, through which the heat exchange fluid can be circulated before it enters the production well.

Development of geothermal energy depends on the discovery of a number of high grade hyperthermal systems, which can be developed in today's energy market at a profit. In a few year's time, as other energy sources become more expensive, and as geothermal technology becomes more credible and cost effective, the more expensive but more abundant geopressured and hot dry rock systems could become economically competitive. In this scenario, it is quite possible that the rate of geothermal power production could reach 400,000 megawatts in three or four decades. However, if few hyperthermal systems are found, the credibility of geothermal energy may never be established, and the more expensive forms may never get beyond the experimental stage. In this case, total production may never exceed 1000 megawatts capacity. The vital question is whether we can inventory our hyperthermal systems reliability and efficiently in the next few years.

How To Inventory Hyperthermal Resources

An inventory of hyperthermal geothermal reservoirs can be accomplished only through a program of geochemical, geological, and geophysical exploration, verified by drilling. Various specialized exploration techniques may be effective in locating geothermal reservoirs.

Geochemical Indicators

Direct evidence of anomalous heat flow is desirable in locating hyperthermal reservoirs. This is provided dramatically by geysers, boiling springs, and fumaroles; less dramatically by warm springs or slightly elevated temperatures in water wells. Such evidence can be reduced to a more quantitative basis by making use of geochemical geothermometers. For example, the amount of silica in suspension in spring water can often be used to tell the temperatures of the reservoir from which that water came. The ratios of various alkali ions in solution can be used in the same way. The techniques are based on the fact that the water in equilibrium with rock in a reservoir will take up characteristic amounts of specific elements. If these waters then migrate rapidly to a surface spring, the ions may not have a chance to re-equilibrate under the new temperature conditions, and be characteristic of the reservoir temperature. Dilution with surface waters or rapid reactions with the rocks through which the erupting waters pass can cause problems. However, favorable geochemical data is strongly encouraging in prospecting for a hyperthermal system.

Electrical Resistivity Surveys

The most diagnostic property of a geothermal reservoir that can be detected remotely is the electrical resistivity. This comes about because a rise in temperature causes the electrolytic solutions which carry electricity through a rock to become more conductive. In a case where the temperature is increased from a normal value of 60 to 100°F to a geothermal temperature of 500 to 500°F, the resistivity is decreased dramatically by a factor of seven. In view of the large size of geothermal reservoirs, which is typically several cubic miles, and this large contrast in resistivity, a geothermal system should not be difficult to detect. Elec-

trical resistivity surveys have long been used on a small scale in engineering, mining or groundwater exploration programs, but rarely on the scale needed to detect geothermal systems. The development of large-scale, or "deep," resistivity surveys for geothermal applications has created a significant new subdivision for the geophysical exploration industry.

Electrical resistivity surveys have become the primary tool used in geothermal exploration, but they do not always provide definitive results. While geothermal reservoirs have anomalously low resistivities, several other rock types, such a shale mases, or sequences of rock saturated with saline water, do also.

Seismicity Studies

Another novel exploration technique which is finding wide application in geothermal surveys is the location of earthquake epicenters. In a survey, an array of sensitive seismographs is set out over a prospect area, at intervals of 3 to 6 miles. These record the occurrence of small, local earthquakes, as well as the more distant ones seen with conventional seismographs. The concept is that local microearthquake activity can be used to locate and identify faults along which geothermal fluids migrate. The excess pore pressure caused by heating of the rock may give rise to a high level of microseismicity within the geothermal reservoir.

Microearthquake surveys over known geothermal reservoirs have shown that all are characterized by locally high levels of activity. It is possible that undiscovered systems may not necessarily show the same phenomenon. It is well known that many nongeothermal areas do exhibit high levels of seismic activity. Despite these problems, the coincidence of anmalously low resistivities with high microearthquake activity is taken to be favorable evidence for the existence of a geothermal system.

Conventional exploration techniques are also being used in geothermal prospecting, primarily airborne infra-red surveys, multi-spectral photography, gravity and magnetic surveys. In areas with well established geothermal systems, all these techniques can be shown to give positive indications of the system. In more virgin prospects, the utility of these methods is sometimes less obvious.

I have stressed the importance of establishing the size and quality of the geothermal resource base as the first and fundamental problem in the development of geothermal industry. The main problem areas in production revolve around efficiency fo electrical generation and environmental effects.

The Problem of Efficiency

The limiting efficiency for deriving electric power from heat energy is given by a law of thermodynamics:

$$\text{Maximum Efficiency} = \frac{T_{In} - T_{Out}}{T_{In}}$$

where T_{In} is the temperature before energy removal, and T_{Out} is the temperature of condensation of the vapor driving the turbine, in the case of electric power generation. Water vapor condenses at a relatively high temperature, and so, use of geothermal steam, obtained originally at temperatures only moderately above the condensation point, limits the efficiency of such systems to very low numbers, ranging from 12 to 20%. Efficiency may be improved by using binary systems, in which a low boiling point fluid is converted to vapor by the geothermal fluid in a heat exchanger. Development of binary systems using freon as the working gas is presently well along.

Environmental Problems

Geothermal energy is often considered to be relatively free of problems in environmental impact. Perhaps the most difficult problem is disposal of waste water, particularly in systems where a mixture of water and steam is produced from wells. Often the water is too saline for any constructive use, and contains undesirable elements such as boron and mercury at potentially hazardous levels. It appears that there is no solution other than reinjection of the waste water into the same reservoir from which it was produced.

Legal and Institutional Problems

The legal status of groundwater, oil and gas, and conventional minerals has been established and defined to a high degree of precision over the years. Geothermal energy is all of these and none of these at the same time. The lack of clear legal distinctions between geothermal energy rights and other property rights is a severe impediment to the orderly development of a geothermal industry.

Will geothermal energy provide a significant part of the solution to our problem of obtaining energy sufficiency in the United States? I believe it will, but only time, in the form of five to ten years of strenuous exploration and development, will tell.

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Dr. George V. Keller is head of the Geophysics Department, Colorado School of Mines. He is a recognized authority on geothermal exploration and development. Dr. Keller is currently engaged in non-School activities, as he employs a sabbatical year's leave of absence to complete various research projects.

—mm—

CSM and Synfuels Development

by Leanne Gibson

The following statement was made by a proponent of oil shale development at Colorado School of Mines:

"Can oil wells produce enough petroleum to meet the enormous demand now existing for oil and its products? The answer is doubtful. Will new oil fields be discovered to meet the increased demand in the future? The answer is extremely doubtful.

Yet this is the age of oil. Oil we must have. The supply must come from our great deposits of oil shale. If oil is the 'king,' then oil shale is the 'heir apparent'."

With the development of the country's vast shale reserves still considered one of the long-term solutions to the country's energy supply problems, the statement could have been made in 1980.

It wasn't. It was made more than 60 years ago by Victor C. Alderson, then president of Colorado School of Mines, in the October 1919 issue of the CSM Quarterly. It was a time when forecasters were worried about the country's 6 million vehicles using more than 3.5 billion gallons of gasoline.

Alderson cited a Bureau of Mines warning that foreign governments were assuming political and economic control of the potential supplies of crude outside the United States, and that conservation measures were necessary to reduce waste and ensure supply.

"Petroleum and natural gas are not being replaced by nature, and once gone cannot be replaced except from sources involving greater costs," Alderson quoted the bureau as reporting.

It's almost too easy to draw parallels between the post-World War I era and the post-oil embargo era of the 1970s and 1980s. The number of vehicles in the United States has increased to almost 144 million, a 24-fold increase from the figures Alderson used, and they use 120 billion gallons of gasoline each year.

And oil shale, as well as other synthetic fuels such as coal and liquids, are being looked to as a partial means of attaining increased energy independence for this country.

During the last six decades, Colorado School of Mines has maintained a close interest in the development of a synthetic fuels industry. The CSM Research Foundation operated the Bureau of Mines' Anvil Points Research Center near Rifle, Colo., from 1964 to 1968, and James Gary, a professor in the chemical and petroleum refining engineering department since 1960, began organizing annual oil shale symposia at the school 16 years ago.

Interest in the oil shale industry waned in the late 1960s, so the symposium was not held for a few years. But with President Carter calling for synthetic fuels to replace 2.5 million barrels of imported fuel a day by 1990, enthusiasm is on the upswing again.

And CSM researchers, with the help of government contracts, are in the thick of the action.

Bob Baldwin, assistant professor in the chemical and petroleum refining engineering (CPR) department, points out that the school's $1 million in research contracts make it "one of the five largest in the nation in terms of synthetic fuels research."

Professors in the CPR department, where most of the research is underway, are looking at many of the basic chemical processes involved in coal gasification and liquefaction. In metallurgical engineering, researchers are examining a welding technique that could significantly reduce the amount of time needed to weld the massive vessels in which commercial-scale synthetic fuel development will take place.

The chemistry and geochemistry department has studied trace elements in the oil shale region of western Colorado, and the school's Earth Mechanics Institute is studying the effect of in situ retorting on oil shale pillars. Other research is being conducted by the mining engineering and mathematics departments.

Baldwin is one who believes that basic research is needed to understand the processes involved in the development of the still-fledgling synthetic fuels industry. The emphasis of the Department of Energy, which is funding most of the CSM projects, however, is on the more expensive plants and equipment, he said.

"The hardware has more visceral appeal because it is tangible, and thus easier to justify," he said. "University research tends to be long range. It may be 20 years, but it will have some impact."

Gary added that a balance must be struck between hardware and basic research. "There is a lot of hesitancy in synthetic fuels, because the first plant is always inefficient, and nobody wants to be the one to build it," he said.

As for the variety of synthetic fuels alternatives, he said, "We need to work on all of them. In the petroleum industry, for example, there will always be the need for additional basic research, and we have been producing for 70 years."

Baldwin noted that a coal liquefaction research program in the chemical and petroleum refining engineering department started out on a very applied basis during the early 1970s but is now stressing a basic approach. "You really can't make improvements in the applied aspects unless you understand the basics," he said.

The project, now in its third stage, began more than six years ago with a study of removing sulfur from coal through solvent refining. Baldwin, Gary and Richard Bain are working on the project, which first involved converting the solid coal to liquid and removing sulfur and ash.

In the process, the Btu content of the coal increased from 10,000 or 12,000 to 16,000, sulfur decreased from 4 to 1 percent, and ash was reduced from 15 percent to zero.

The second phase of the project looked at the solvent refining process on a larger scale. The research resulted in the school having the only operating continuous flow bench scale coal liquefaction system in the country in a university atmosphere, according to Baldwin.

He said, "We were the only university that attempted to do experiments on a scale comparable to that used in industry."

The third stage of the project is taking

the researchers to what Baldwin termed "more traditional chemical engineering work," a study of the kinetics involved in the process. "We hope to make some fundamental contributions to the science of coal," he said.

Vic Yesavage, an associate professor in the department, spent three years with department head Philip Dickson studying whether shale oil would be an appropriate chemical feedstock. Putting two different shale oils through a distillation process, they determined that even the weak oils produced more ethylene than is normally produced.

Yesavage said the research has long-term implications and is "three years ahead of its time." He said, "Shale oil will be around for a very long time. In 100 or 200 years, it will be the only fossil fuel available for petrochemicals. We can come up with all sorts of alternatives for other energy uses, but chemical companies are getting worried about future supplies of stock."

Yesavage and Art Kidnay, a professor in the department, are working on another project to predict the enthalpy, or physical and thermodynamic properties, of coal liquids. Kidnay said they have designed and built the equipment and measured the data base.

The next step is to develop a final engineering correlation so that measurements won't have to be made on each sample of coal liquid.

Michael Grabowski, an assistant professor in the department, has finished a project on microwave pyrolysis of coal, which examined whether the process increased yields over conventional techniques. He is working now to adapt the process for biomass gasification, which he said is expected to produce more favorable results than it did for coal.

He and E. Dendy Sloan, an associate professor, have developed an instrument to measure the thermal conductivity of synthetic fuels with the idea that thermal conductivity is a basic parameter for heat transfer.

In another project, Sloan is studying a new process for producing carbon monoxide and hydrogen from carbon, in the form of coal, and water. The point is to try to get the product in the form of combustible fuels, said Sloan.

On a more applied level, Anthony Hines, an associate professor, is working on two research projects—one to clean up retort water from in situ oil shale processes, and the other to use the spent shale from retorting to produce liquids and gases.

The retort water can be cleaned by a hot gas stripping process, in which the water is put into contact with hot gases, causing the pollutants to separate and leaving pure water at the end of the process. In secondary processing, resin or activating carbon is used to remove organic materials that are not removed with the hot gas stripping process.

Although the chemical and petroleum refining engineering department is leading the school's efforts in studies of synthetic fuels, other departments also are doing work in the area.

In metallurgical engineering, department research is focusing on a study of electroslag welding for use in welding together the 160-foot cylinders that will be used for coal liquefaction.

Jerald Jones, assistant welding research professor, said the electroslag process is much less time-consuming than the traditional arc welding process, but that it has a reputation of poor fracture resistance.

Using steel with a ratio of 2¼ parts chrome to 1 part molybdenum (donated by Stearns-Roger), the research is examining the travel speed of the weld in the continuous electroslag process, as well as voltage and current. A study of the interaction of the three has shown there is a minimum and maximum critical heat input needed to provide the strongest weld, said Jones.

The project is only one of the several on welding research being worked on in the department, which has about $1 million a year in welding research funding.

In other synthetic fuels research Ron Klusman, a professor in the chemistry and geochemistry department, has completed reconnaissance work on stream sediments, surface soils and selected plants along the Colorado River on the federal C-a and C-b tracts as well as at the Anvil Points site.

The study, as well as associate professor Tom Wildeman's work on mass balance studies on oil shale retorting, are part of a larger DOE study being done in conjunction with the University of Colorado and Colorado State University.

The school's involvement in synthetic fuels extends beyond research. Baldwin teaches a course on synthetic fuel processes. Yesavage and Dickson teach a continuing education course on synthetic fuels, and members of the department are discussing the possibility of a class geared toward the public.

Gary, the former vice president for academic affairs and dean of the faculty, is chairman of an Office of Technology Assessment subcommittee on oil shale. The group has advised the OTA on a major oil shale study for Congress that examines the technology, economics, risks, and policy alternatives for oil shale development in the United States.

And Dickson is writing a chapter on oil shale for the third edition of the Encyclopedia of Chemical Technology.

The school's relationship with oil shale and other synthetic fuels development has been a lasting one, and one that promises to grow as the country's concern with unreliable sources of foreign oil mounts.

The research going on at the school shows that the development of a synthetic fuels industry is complex, much more so than realized by early proponents such as the late CSM President Alderson.

In 1919 he wrote, "In the minds of those men who are best informed on the technical and business phases of the oil shale industry, it has passed the experimental stage and 'has arrived'."

Six decades later, Gary says of the industry, "We need to get started sometime. How feasible synthetic fuels development will be will depend on the competitive prices of fuels at the time. It's not that far off, when you talk about clean fuels."

Leanne Gibson is the former Public Information officer at CSM. She has recently resigned from this position to pursue a Master's degree in Mineral Economics at the School. Ms. Gibson is a graduate of Colorado University.

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Synthetic Fuels

by Rod Geer

Transportation in this country consumes 10 million barrels of oil per day. This represents about 26 percent of all energy used in the U.S. daily and more than half the oil. The private automobile, in turn, consumes more than half of the transport sector's energy. The energy crisis is, in large part, an inability to supply form domestic resources the crude oil necessary to fuel the transport sector.

While it is difficult to conceive of synthetic liquid hydrocarbon fuels produced from oil shale and coal as replacing a major portion of imported crude oil, the successful development of economically viable oil shale retorting and coal liquefaction processes could make a significant contribution to reducing U.S. dependence on foreign crude oil resources.

Private industry will develop these processes. Sandia laboratories is conducting supportive research and development projects to assist industry in better understanding critical phenomena and, hence, in improving process efficiency. These projects are sponsored by DOE's Division of Fossil Fuel Extraction and Fossil Fuel Conversion.

Oil Shale

Efforts to recover hydrocarbons from the nation's vast deposits of oil shale have, until recent years, been focused on surface processing methods. Such methods require the shale to be mined, transported to a processing site, crushed and screened, and then heated in a retort vessel to convert the solid organic constituent (kerogen) in the rock to recoverable liquid and gaseous hydrocarbons. While the technology for surface processing is proven, application on a scale broad enough to significantly impact the nation's demands for petroleum products may not occur because of concern about surface damage, water requirements, and spent shale disposal. Additionally, economic constraints will restrict use of these methods only to oil shale seams which satisfy certain richness, thickness, and accessibility criteria. The prognosis for the Green River Oil Shale Formation in Colorado, Utah, and Wyoming is that about two-thirds of the estimated two-trillion barrels of oil in place cannot be recovered by surface processing methods.

To improve the efficiency of resource utilization, as well as to mitigate adverse environmental impacts, efforts are underway by the DOE and private industry to develop methods to process oil shale underground. These in situ methods fall in to two general categories—true and modified. In either case, an underground retort bed is formed, typically by explosively fracturing and fragmenting the rock. Subsequent processing occurs, in most instances, by using heat generated by burning a carbon residue left in the shale after the hydrocarbons have been freed. By definition, true in situ methods involve no rock mass removal during bed preparation, except for that produced in drilling wellbores to gain access to the underground formation. With modified in situ concepts, access can be gained through mine shafts or tunnels and rock mass removal is a basic feature. A typical modified in situ bed preparation operation includes creation of a mined cavity into which rock from the surrounding formation is blasted to form a rubble, or retort, bed with a void fraction of 20 to 30 percent. Except in shallow formations, where overburden lift can be achieved with explosives, true in situ retort beds are characterized by much lower void fractions. The void fraction difference implies that fluid-flow properties also differ; the result is that modified in situ processing methods offer a greater chance for near-term success than do true in situ methods. As a result, the bulk of DOE's oil shale research effort is currently directed toward developing viable modified in situ processing methods.

Sandia's oil shale projects are multifaceted, focusing in large part on modified in situ processing, but also bearing on true in situ processing and surface processing. Activities include laboratory and field experimentation and theoretical analyses. rock fracture and fragmentation, rock mass and rubble pile stability, process chemistry, and instrumentation tehcnology.

Field programs are conducted at various sites throughout the country to monitor and evaluate explosive fracturing and retorting operations. The work is done in conjunction with the Laramie Energy Technology Center. Instrumentation systems are used to monitor the dynamic events that occur during a blasting operation, to evaluate the physical state of the formation both before and after a blast, to monitor and control retorting operations continuously, and to provide information about the stability and integrity of a rubble bed and the surrounding rock mass before, during and after a retort.

Laboratory studies and theoretical analyses support the field activities in various ways. For example, study of the static and dynamic mechanical properties of oil shale has led to the formulation of computer models to quantitatively describe explosive fracturing events. The immediate payoff of these studies is that instrumentation systems for field experiments can be effectively designed and operated. Ultimately, however, the laboratory, field, and theoretical work will lead to the ability to confidently prepare rubble beds for processing. Work in rock mechannics also is being used to study the strength and creep of materials at ambient and elevated temperatures to provide information on subsidence or collapse of underground rubble beds or surrounding rock masses.

Evaluation of the physical state of a rubble bed (fragment dimensions, void ratio, fluid-flow properties, etc.) is addressed through development of remote sensing devices and instruments used directly in the rubble. Particularly noteworthy is a flow evaluation system which, by means of time-resolved measurements of the transit of tracer elements between pairs of wellbores, is capable of providing spatially resolved information not only about flow, but also about the void volume of the flow path. Methods to enter a rubble bed nondestructively for direct examination (core extraction, TV, etc.) or for instrument emplacement are also under investigaton. Remote sensing devices (acoustic, electro-magnetic, resistive, etc.) are being developed for use when intrusion into a rubble bed is not feasible.

Many of the techniques applicable in rubble bed evaluation can be used in monitoring retorting activities. Remote sensing devices or instruments in the bed are needed to provide continuous information about temperature profiles, input and output gas compositions, product status, etc. Computerized methods to handle the data acquisition and analysis aspects of these tasks have been developed in basic form and are being refined and modified for new applications. Theoretical descriptions of process chemistry have also been developed. The non-uniform flow (channel flow) characteristics expected in in situ retorts have been emphasized, as opposed to the uniform or packed-bed flow characteristics that can be achieved in a surface retort.

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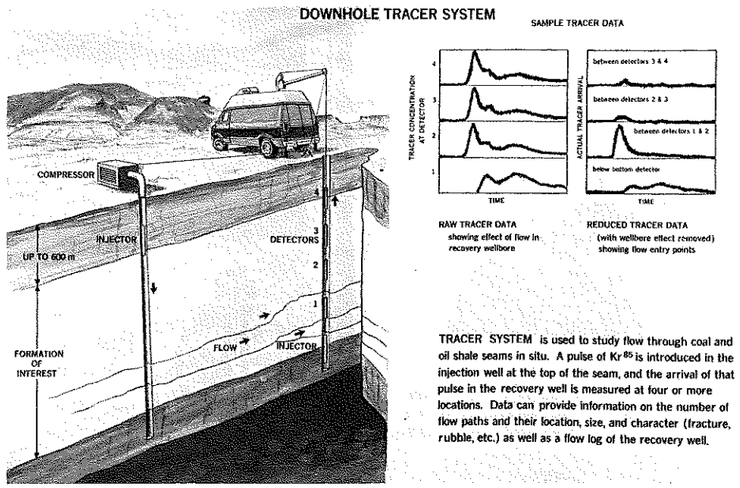
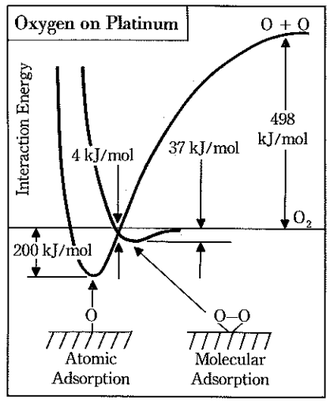


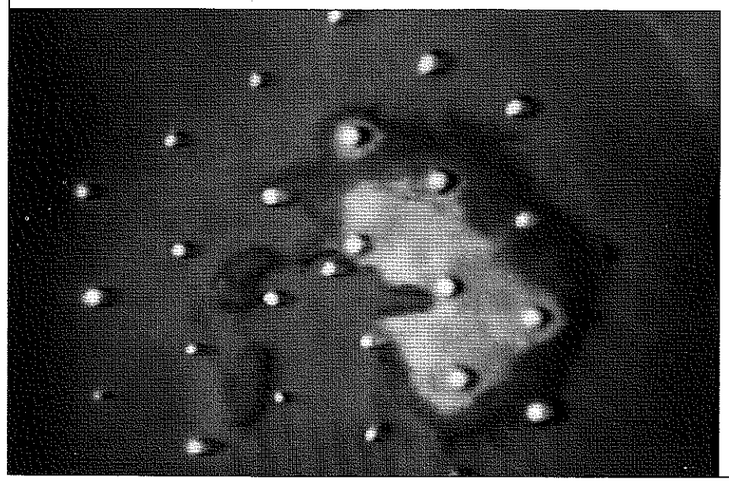
TRACER SYSTEM is used to study flow through coal and oil shale seams in situ. A pulse of Kr^{85} is introduced in the injection well at the top of the seam, and the arrival of that pulse in the recovery well is measured at four or more locations. Data can provide information on the number of flow paths and their location, size, and character (fracture, rubble, etc.) as well as a flow log of the recovery well.

The Atomic Arrangement

In a recent experiment, scientists at the General Motors Research Laboratories studied changes in chemical bonding during the dissociation of oxygen molecules on platinum. Preliminary surface work has explored an interesting new phenomenon: the mechanism of oxygen dissociation over a wide range of temperatures.



A simplified schematic illustrating the reaction potential energy surface for oxygen-adsorption on a close-packed platinum surface.



An electron diffraction pattern which shows diffraction patterns from an oxygen-covered hexagonally close-packed platinum surface at 0° C.

UNDER what conditions will oxygen molecules dissociate into single atoms on a platinum surface? What is the mechanism for oxygen dissociation? Those are the kinds of questions that Dr. John Gland and his colleagues at the General Motors Research Laboratories are investigating to get a better understanding of the chemistry behind catalysis.

Their work has valuable practical implications for the automotive field, where catalysis is used to remove harmful emissions from automobile exhaust. Most cars built in the U.S. use catalytic converters filled with beads containing platinum to chemically transform carbon monoxide and unburned hydrocarbons into harmless CO_2 and water.

While it has long been known that catalysts are an effective way to convert these gases, little is known about precisely why and in what order the basic atomic reactions occur.

In seeking answers to these questions, surface chemists study the elemental composition and geometric arrangement of atoms in the first few atomic layers of the surface and the means by which atoms and molecules from the gas phase bond to the surface.

In his most recent work, Dr. Gland has been studying the adsorption and desorption of oxygen on platinum single-crystal surfaces. This is important because oxygen is the agent that must be adsorbed on the surface to react with carbon monoxide and hydrocarbons to convert them to CO_2.

The experiments were conducted in a stainless steel ultrahigh vacuum system equipped with an electron energy analyzer and a mass spectrometer. The electron energy analyzer allows one to measure the concentration and character of the oxygen adsorbed on the platinum surface. The mass spectrometer is used to measure the desorption of O_2 as the platinum surface is heated. Mathematical analysis of the desorption process allows one to characterize the chemical bond between the oxygen and the platinum surface.

In these experiments, the platinum surface is covered with oxygen at the extremely low temperature of −179°C (almost the temperature of liquid nitrogen) by exposing it to gaseous O_2 molecules. The oxygen remaining in the gas phase is pumped away, and then the desorption of oxygen from the surface is observed as the platinum crystal is gradually heated to 1000°C.

The oxygen was found to desorb from the surface in two distinctly different temperature regimes—part at −125°C and the rest at about 425°C. By using the oxygen-18 isotope, it was established that the low temperature desorption represents oxygen that was adsorbed on the surface in a molecular form while the higher temperature desorption corresponds to oxygen adsorbed in the atomic form. From an analysis of the desorption process, it was possible to establish the complete energetics. Oxygen molecules from the gas phase strike the surface and are weakly bound (37 kJ/mol). The adsorbed oxygen molecule can either desorb into the gas phase (37 kJ/mol) or dissociate into atoms (33 kJ/mol). The atoms are bonded very strongly (200 kJ/mol) to the surface.

FROM the desorption analysis, it was also possible to deduce the mechanism for the dissociation process. The interesting conclusion that results is that the formation of O atoms on platinum is a two-step process—oxygen is adsorbed in a molecular state and then dissociates to form atoms.

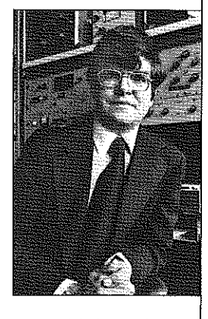
The GM scientists were most interested in learning how this adsorbed molecular species is bonded to the platinum surface. Fortunately, another technique was available to determine the bonding. The technique is called electron energy-loss spectroscopy and is quite new—there are only six or seven such instruments in the world. The measurements not only confirmed the existence of the adsorbed molecular oxygen but showed that it was bound by the transfer of two electrons from the platinum surface into the antibonding π_g orbitals of oxygen. "This was most exciting" said Dr. Gland, "because this is the first time that this type of oxygen bond has been observed on a metal surface.

"We're getting closer and closer to a more specific understanding of catalysis," says Dr. Gland. "The more we learn about simple chemical systems, the better we'll be able to control more complicated systems. That has excellent implications for protecting the environment."

THE MAN BEHIND THE WORK

Dr. John Gland, 32 years old, is a Senior Research Scientist in surface chemistry at the General Motors Research Laboratories. He heads a group of 7 investigators, 4 with Ph.D.s, all involved in work relating to the basic surface chemistry of catalysis.

A graduate of Whittenberg University in Ohio, Dr. Gland received his Ph.D. in physical chemistry at the University of California, Berkeley, in 1973 and joined the General Motors staff that year.



Dr. Gland comments: "I came to GM Labs because I wanted to get in on the ground floor of an exciting new field. The atmosphere here is very open, with lots of cross-pollination among departments. With several hundred people with Ph.D.s here, we've got a lot of human resources to draw on in all the basic sciences.

"Typically, management defines a broad problem, then we're free to tackle the solution in any way we choose. They give us the freedom, equipment and support to get the job done correctly."

In addition to his research, Dr. Gland enjoys backpacking in Wyoming and in the Sierra Nevada Mountains in California.

Wave Power for Britain?

by Peter Rodgers

Mr. Rodgers believes that as an alternate energy source, wave power development deserves government funding on a limited scale, but that some of its advocates take their enthusiasm to unwise extremes, their arguments echoing those which led Britain into such commercially disastrous technological ventures as advanced gas-cooled reactors and Concorde. A recent book on wave energy, *Energy from the Waves*, Pergamon Press, calls for massive spending and says it should be regarded almost as a public works programme, aimed at developing the technology whatever the cost. Mr. Rodgers maintains there is no case for such an abandonment of economic and industrial commonsense.

There are perhaps 150 people in what has come to be known as the 'wave energy community', the groups of scientists and engineers at universities, government laboratories and in industry who are developing devices for extracting electric power from the sea. It took boundless enthusiasm for them to get where they are today, by struggling uphill against a government bureaucracy which sees spending on renewable energy sources merely as an insurance policy in case something dreadful happens to oil, coal or nuclear power supplies.

But this admirable kind of technological enthusiasm can sometimes have its darker side, reflected at its worst, over the last two decades in the nuclear power and aviation industries. Emotional battles have been fought over vast projects for and against advanced gas-cooled reactors or American pressurised water reactors, for and against Concorde—on grounds which have little to do with economics, common sense and efficiency, and a lot more to do with a kind of technological chauvinism, almost jingoism—we will show those rotten foreigners that we can build the best in the world, and never mind the cost or the markets.

Intertwined with this has been a naive belief that some great technological leap could win back a place in world markets already lost through inefficiency in selling run-of-the-mill things. So in telephone exchanges British companies unsuccessfully try and jump several generations ahead with the great System X, and in supersonic transport Concorde is produced as the answer to failures in marketing ordinary, unglamorous airliners. There is a very similar strand in the UK Atomic Energy Authority's argument for leaping ahead to the fast breeder reactor at a time when the more conventional British nuclear industry is in a dreadfull mess.

It would be most unfair to accuse the fledgling wave energy community of the stresses of the huge nuclear and aviation industries. After all the hard work, the government has so far only allocated £5•4m for research and development, a tenth of the cost of one big-semi-submersible drilling and fire-fighting vessel recently ordered for the North Sea. There are doubtless very strong arguments for depending more on wave energy over the next few years. Yet here and there, echoes of those other more insidious and potentially damaging arguments begin to seep in, and they need watching, if Britain is not to suffer another AGR or Concorde fiasco. They are reflected in the book by David Ross which is billed as the first-ever book on a revolution in technology.

Act as if at war

Mr. Ross suggests that in considering wave power the Secretary for Energy should act as though there was a war on. He should imagine what action he would be taking today, if for instance, the Middle East was suffering a nuclear attack, the Common Market countries were demanding a share of our oil and coal, and the energy famine, which is certain to come sooner or later, had already arrived. He draws parallels between wave power and the aircraft industry's priority status in the last war and says: 'Let them say what they want and it would be produced'. Money would be less valuable than time. A government wave energy programme costing £200m to £250m 'could transform the energy scene in a way that could not be done by investing that amount in any alternative—either conventional, or nuclear or other benign sources'.

Then, says Mr. Ross, if the government found itself facing an immediate energy crisis 'it could without fear think in terms of a £1,000m investment in wave energy, knowing that even if the calculations . . . should all prove to be optimistic, and even if we obtained less power that forecast, we should still be certain of making some contribution to our needs and the world's, by absorbing the power of the waves'.

He also suggest that: 'The initial cost of construction can be and, in my opinion, should be regarded as an element in a public works programme, providing useful employment in a slump. After that the cost of maintenance, compared with the cost running and maintaining a coal mine, will be small'.

But Concorde was something of a public works programme, and is hardly a model to aim for. The entire development and prototype has been borne by the taxpayer, and written off, leaving the marginal extra cost of production of each series model to be paid by those unfortunate airlines which operate it (still at a heavy loss).

In the same vein, of stirring exhortations to action, Mr. Ross suggests 'We shall not know for certain until the generators are on site. It may then well be that those of us on the shore, whose innocence is matched only by instinct, may well be more right than the experts in urging a swift leap ahead', Mr. Ross says that old mariners' stories about the size of waves have been proved right by modern records of giant waves, up to 34 metres high. 'Instincts,' he says, 'are not always wrong'. However, they have rarely been used as fundamental justifications of billion pound investments.

Mr. Ross commends the Japanese for spending much more on wave energy than Britain, and is critical of the way British engineers are creeping ahead slowly, test by test. He says that it is in 'the repeated tests and the stage by stage upscaling, and the feeding of information into the computer before venturing too far, which is where we differ from the Japanese'.

Later, he adds that 'The question, which is a political one, is whether it is better to delay in order to find the best system, or revert to the old British habit, which the Japanese have now acquired, of a pragmatic approach . . . . It would be sad now to have to watch the Japanese charging ahead in the best British manner while we cautiously pursue a scientific approach'.

In answer to that point it is worth recalling the endless soul searching in the British nuclear industry as the advanced gas-cooled reactor programme collapsed into chaos in the late 1960s and early 1970s. The consensus was that the fundamental mistake was to leap from a small 30 megawatt prototype at Windscale to a full scale power station, a technical jump which was far too rapid to cope with.

Cavalier about costs

Mr. Ross is also cavalier about costs. He says 'If we have to pay more for wave electricity, then we must recognize the fact; the alternative is to burn up the possibly cheaper, limited fossils knowing that one day the joy ride will lurch to a stop'

Exhortations such as these, which are used to justify quite a few energy research projects, really boil down to saying that there is some value in wave energy that ordinary economic and industrial judgements have missed, some special benefit because it is a renewable resource. (It is anyway not entirely true that it is renewable, in the sense that a vast amount of machinery is needed to extract it. This needs large quantities of non-renewable energy to manufacture, and it eventually wears out and has to be thrown away.)

The implications of arguments like those of Mr. Ross is that it does not matter if a project cannot be made to pay on paper—go ahead anyway, to save fossil fuels. This is simply not good enough. It is an arguable point that conventional wisdom understates the scarcity of fossil fuels and the speed with which prices will rise. But it certainly does not make sense to say that Britain should pay over the odds, on a risk venture, *merely* to save oil and coal, without regarding to what the actual prices are likely to be. Mr. Ross comes close to saying this.

But even if wave energy does look like becoming competitive because of rising energy prices, is that enough? Might there still be other projects which should take priority, perhaps less technically risky ones? With the AGR fiasco in mind, is the case for wave power so overwhelming that we should take the real risk, which always accompanies an early start on large scale investment, of choosing the wrong sort of wave power technology?

British industry has often missed the boat on new products not, as often supposed, by being too late, but by being too early. This has led to too much expenditure in the development stage, before it has been possible to see clearly how the market will crystallise, thereby getting frozen into the wrong batch of a technology. Somebody else with better timing invariably comes along later and makes a real business out of it.

The industrial and commercial aspects are important, because they create new business jobs and investment which can be multiplied by exports of designs and machinery. It is also shortsighted to develop new devices only for the home market, but it keeps happening, and is another result of starting too early, particularly where nationalized industries are customers. The VC 10, developed partly for British Overseas Airways Corporation's special requirements, but a sales flop overseas, is a classic case. So are Britain's almost unexportable telephone exchanges, developed specially for the Post Office, and the AGR nuclear power stations.

Mr. Ross compliments the Japanese, well known for getting their timing right and sweeping world markets before them, for leaping into wave power on a considerably bigger scale than Britain, with a £22m programme. It could be argued that this reflects Japan's dangerously high dependence on energy imports, a vulnerability which Britain does not share.

Self sufficiency in energy is often vaunted as a desirable end, *per se*, with the implication that Britain, like Japan, must use every means available to increase supply, almost regardless of cost. Similar arguments have been used in other areas to get government money to develop completely British technology, when cheap alternatives exist abroad, on the unquestioned assump-

tion, which is quite wrong, that Britain ought to be self-sufficient in ideas.

Britain's favourable position

The justification for energy self-sufficiency as an end in itself, whatever the cost, is particularly hard to find, given Britain's energy position. What matters most is that this coutnry is relatively better off than almost all her industrial competitors and is likely to remain so beyond the end of the century, even after the decline in oil production sets in. A contribution to national self-sufficiency should never be accepted as an overriding argument for an energy project, be it keeping open a high cost coal mine or investing in wave power. There is no reason, in Britain, for putting wave power on the supra-economic war footing which Mr. Ross recommends. Indeed, even if this emergency approach proved necessary, other investments—particularly in conservation—should have a far higher priority, as crash programmes, than wave power, because the risks are less and the rewards greater.

This is not meant to be a tirade against wave power, but rather a case for continuing to use ordinary economic and industrial commonsense about its merits, for refusing to jump the gun. It is not just the gee-whiz technologies which risk doing this. The shipping industry has leapt into the liquid natural gas business a decade to early, because forecasts of booming trade proved too optimistic. A similar realism seems to have struck the wave power community in Britain at least a year ago, before Mr. Ross's book was published.

A conference on wave energy in London in November 1978, the first of its kind, made it clear that the problems are looming larger than the solutions. This was the result of engineering evaluations of four different systems, carried out by the consulting engineers Rendell, Palmer and Tritton, in association with Kennedy and Donkin. Wave electricity was estimated to cost from 20 to 50p a kilowatt hour at a capital cost of £5,000 to £9,000 an installed kilowatt. These are ten to twenty times present electricity costs.

The reasons are the high cost of large steel and concrete structures, a scaling down of views of how much power is available from the waves themselves, and high maintenance costs.

There is also the very difficult problem, which the book skates over, of matching wave energy to the electricity grid. This involves large investment in pumped storage schemes, or possibly air storage. While wave power is greatest in winter, when electricity demand is at a peak, it is still subject to wide variations and storms will not arrive conveniently at each evening peak of demand.

A dose of realism may concentrate the minds of engineers, and out of it could come a technical breakthrough, who knows? Until then, beware enthusiasts bearing requests of large sums of money.

Reprinted from: Coal and Energy Quarterly, NCB Public Relations, National Coal Board, London, England, Number 22, Autumn, 1979.

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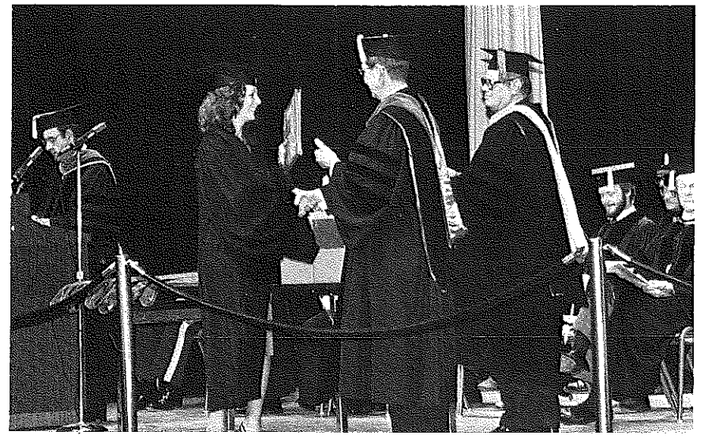
Mid-Year Commencement



Dr. Michael Nyikos, Dr. Guy T. McBride, Jr., and Dr. William Mueller officiate at the awarding of diplomas during the Mid-Year Commencement ceremonies.

Commencement has become a twice-a-year event at CSM, with the growing number of graduates who obtain degrees in the December graduation ceremonies. The change has been brought about for many reasons; including the fact that some students now leave school for a semester's cooperative education program, that enrollment continues to rise, and to the fact that demand for mineral engineers continues to accelerate. For graduate students, on more flexible schedules than undergraduates, the December date has always been important, but this year the graduate group was greatly outnumbered by the undergraduate degree recipients. 134 undergraduates and 81 graduate degree candidates received diplomas on Friday, December 21.

Dr. Albert W. Schlechten, a member of the faculty since 1963, and director of the W. J. Kroll Institute for Extractive Metallurgy, was chosen by the faculty committee to address the graduates. Dr. Schlechten's speech, "Who Gets Ahead?", was well-received by the graduates and assembled families and friends.

Degrees were presented by Dr. McBride, the Board of Trustees and heads of various departments.

The traditional reception, hostessed by the Faculty Wives' Club, rounded off graduation day for the new engineers, masters and doctors.

The CSM Alumni Association participated in the mid-year festivities by holding the first banquet for this event. Over one hundred and fifty alumni, graduates, parents and friends gathered in Friedhoff Hall on December 20, to welcome the new graduates into the alumni group, to enjoy an evening of renewing old friendships and forging new, and to listen to leaders of the Alumni Association and School, who gave brief speeches. President of the CSMAA, Bob Brace, welcomed the graduates into the Alumni Association, George Mitchell, Director of the CSMAA acted as MC, and added his hearty welcome to the group, and the Alumni Board presented David Cole, E.M. '52, with an honorary membership in the Association.

Dr. William Mueller, MSc. Met. E. '52, PhD. Met. E. and Medalist, spoke on the relationship of the School and the Alumni Association, pointing out the mutual advantages of the interaction.

Some very pertinent and interesting information on the School was the subject of a brief address by Dr. Guy T. McBride, Jr., (see box), who congratulated the families of the graduating students on the attainment of their family members.

The enthusiastic response of the graduates, alumni and families makes for an almost positive repeat scheduling for next-year's Mid-term Commencement banquet.

Many questions are asked about the state of engineering schools in general, and, from our alumni and friends, the state of Mines in particular. Answering some of the questions dealing with students and their interest in engineering today, a brief study of Mines classes has been done by the Registrar's office, under the direction of Dr. Harold Cheuvront, Registrar. A direct response to questions posed by the Trustees of CSM, the study had some illuminating points.

Sampling of freshmen classes for the years 1969-75 were undertaken, to determine the percentage of student graduation/retention, minority student retention, and the rate of female completion of studies. Comparison figures were obtained from the National Center for Educational Statistics. The cut-off date of 1975 was used, since the class of 1976 would not have fully moved through the four-year program.

The national percentage rate comparison for all students remaining in school and completing a program, in all institutions of higher learning, is 51.1%. Mines students completing their chosen engineering program averaged 57% overall.

Sampling of minority students showed, from 1975-1977, that of a total of 83, 57 students graduated or are still in school, with a retention percentage rate of 68.7%.

The rate for female students sampled was slightly lower than the institutional rate. 319 women students entered and 178 graduated, or are still in school, for a retention rate of 55.8%.

CSM appears to be above the national level in retaining students, and has had above average success in the areas of minority and women students completing study programs.

letters

Dear George:

I am sending in a contribution to the AADF because I agree with you that "a strong, highly regarded Colorado School of Mines is important to each one of us" and to our Nation. It therefore also grieves me more than words can express that the *Mines Magazine* represents the School and the alumni so poorly. Never a class act, the *Mines Magazine* depicts a lassitude that is totally unbecoming to the school. The magazine needs some technical credibility, and the easiest way to accomplish this is to present in each issue short but well-written features and notes on current research programs being done by faculty, graduate students and others associated with the school. If this cannot be done, CSMAA should consider getting a new editor who can evaluate the technical image of the school.

Sincerely,

Norman E. Goldstein
Geol-Eng '57

Dear Norm:

Thanks very much for your November 20th letter concerning Mines Magazine.

I appreciate your comments because it gives us a different viewpoint than we generally receive. The usual response during the last 3-4 years has been that the Magazine has improved greatly. I've enclosed a memo to our editor which outlines the general direction for her to take. This was a result of a considerable discussion within the School, the Alumni group and others in industry. The consensus was that we should not try to be a technical publication. The professional and technical society's publications have developed their capabilities as technical publications and have largely usurped our market. As a result we've tried to move in some new directions.

I think Pat's done well, given the rather limited space she has available. We have found that it is very difficult to obtain short, well written features and notes on current research here at the School or elsewhere.

That's not to say that we don't use technical materials, but I do think we have to have it presented in a way that can have more broad appeal than a relatively narrow, highly specialized presentation with extensive technical content.

Again my thanks to you for your thoughtfulness in writing. Thanks very much for your continued support of and concern for the Association.

Cordially,

George W. Mitchell, Jr.,
E.M. '53
Executive Director, CSMAA

Dear George,

I was pleased with the general look of the recent issue of the *Mines Magazine* (December 1979). The story entitled "Edgar Mine Put to New Use" was exactly what I had in mind as a short note on a current research program at Mines. As we have found here at LBL, these stories are better written by a professional writer rather than the principal investigator. I was also happy to see authors' biographies added at the end of the articles.

I read your letter concerning policies and directions of CSMAA publications and I have no criticism of your editorial concepts for the *Mines Magazine*. I would suggest, however, one further addition that you might wish to make to the content of the magazine. That is, to include reviews of books written by Mines faculty and alumni or books of special interest to the readership.

I look forward to receiving future issues of the *Mines Magazine*.

Sincerely,

Norman E. Goldstein

January 3, 1980

Dear Norm,

Thanks very much for your thoughtful input on this question. I've passed on your suggestions, which I think are good, to Pat Petty for use in the magazine in the future.

Best regards,

George Mitchell, Jr.

To CSM Alumni Association,

I note that you have a space on the information questionnaire for our nicknames.

My nickname was "Moon" when I entered the Colorado School of Mines in '26, the same later, at the University of Oklahoma. In the early '30's, the nickname persisted in the oil fields and in the mines. My first job requiring a business card was in '39. I felt pretty fancy and dropped the nickname. The trade told me to put "Moon" on the card, or they would not let me on the property—they did not recognize me without it. So be it, to this day. It has served me on every continent. In fact, I retired three years ago, have a surplus of cards on hand—will include one, to prove the point.

In looking through the Directory, I did not recognize a good friend—listed as R. B. Downing. He was always called "Ike." I am much in favor of the use of nicknames—where the person agrees.

I have been listed as retired from Atlas Chemical Industries, Inc. This firm no longer exists. It was bought by ICI, whose name in this country is ICI Americas Inc. The word RETIRED is quite sufficient.

R. L. "Moon" Mullen

Dear Ms. Petty,

I certainly enjoyed your article "Beyond Stridency" in the November issue of MINES Magazine. The general theme of the article applies to many other businesses and especially to the nuclear business, that I am in. You could easily replace the words mining industry in your article with nuclear industry. I am very concerned that many of our business leaders continue to ignore the need to educate the public and to operate their business in the manner that avoids concern about their credibility and business ethics.

I hope that you will continue to enlighten business management. Our free enterprise system is in serious trouble if our business managers don't wake up soon.

Very truly yours,

Charles J. Baroch '54.

Editor's note:

Many thanks to Mr. Baroch for his support and interest! An upcoming issue of MINES Magazine will focus on the nuclear industry. I would be most interested in receiving commments from our readers on the advantages and disadvantages of nuclear power and its management in the U.S. and the world today. If you have an article of significance for the industry, please submit it, typed double-spaced, to us for consideration. We are eager to assist in public understanding of this and other extractive industries today.

Patricia Curtis Petty,
Editor

sections

NEW YORK

The November meeting of the New York was the occasion for a visit by C. W. "Bud" Leeds, of the CSM Foundation, who gave the group an updated report on the progress and plans of the Resource Fund program. Those attending were: Bill Breeding, '39; Norm Donald, '39; Herb Goodman, '48; Ned Wood, '48; Charlie Irish, '50 and his wife Joan; Jay Spickelmier; Allen Schedlbauer, '64; Baily Price, '23; Newell Orr, '54.

This group of politically interested alumns carried out their straw poll voting on the national candidates. To be tested against the realities of the conventions in 1980 are the following results: 66% feel that a Republican candidate will win. 50% said Connally would be the Republican candidate with Bush, Reagan and Baker mentioned. Carter and Kennedy had a 50-50 split on the nomination for Democratic candidate. It will be interesting to see how perspicacious these political pundits are!

alumni update

'35 Norman J. Christie, Geol.E, has recently retired from Teledyne Exploration, Ltd. **George W. Reed, E.M.,** is vice President of Well Stimulators, Inc. He is also occupied in activities in Exavier Custom Homes, Inc.

Stephen Hui

'40 Stephen S.F. Hui, Geol.E. and E.M., Chairman and Director of the Yan Hing Mining Company, Ltd. and Chow Hing Investment Co., Ltd., will be honored in March by the conferring of an honorary degree of Doctor of Laws from the University of Hong Kong. Mr. Hui has been extremely active in the affairs of the University and of great assistance to them. A new building on the campus of the University is named in honor of Mr. Hui's father. He has also been instrumental in expanding the knowledge of the people of Hong Kong in the geological sciences by donating excellent collections to the Hong Kong Museum of History and the University.

'41 Ocean Minerals Co., which develops technology and hardware to mine and process deep ocean minerals, has announced that **Glen H. Lancaster, P.E.,** has been named president of the firm, effective in early November. He has been production manager of the African and Middle East region, AMOCO International, and held a number of engineering and management positions prior to this.

'47 Bengt Georg Fagerberg, E.M., has been promoted from his post as director, R&D, to that of Vice-president of Lnossavaara-Kiiranavaaro AB, Lidingo, Sweden.

'49 Hazen Research, widely known Golden firm, has announced the appointment of **Robert B. Coleman, Met.E.,** as Vice-president. Mr. Coleman, with the firm since 1970, has been project manager and senior process engineer. He has been responsible for process engineering and design and many other areas. **Charles R. Fitch, E.M.,** is President of the Charles Ringer Company, specializing in mortgages, real estate and insurance in Chicago, Illinois.

'50 Melih I. Genca, P.R.E., is assistant General Manager, Turkiye Petrolleri, A.O. Gulf Mineral Resources' new Manager of Uranium Exploration is **James S. Hastings, Geol.E.** Hastings will be based in the Denver office and responsible for Western activities of the firm. **Bernard A. Maas, Jr., P.R.E.,** has moved from manager, Merchandising Service, Standard Oil Co., to the post of manager, Petroleum Production for AMOCO Oil Co.

'51 Robert L. Menk, P.R.E. and Medalist, 1973, has been elected chairman and chief executive officer of the New Mexico and Arizona Land Co. effective January 1. The company owns two uranium mines and mineral rights to 1.3 million acres in the Southwest, according to the Wall Street Journal. Mr. Menk is a consultant specializing in energy operations.

'52 James Massey, E.M., is general superintendent of the Union Carbide uranium mine and mill, based in Grand Junction, CO. Massey, who underwent open heart surgery early in 1979, has recovered well from the procedure and is enjoying his new responsibilities. **Edgar Hunter, E.M.,** had major surgery in November in Denver. Ed, who is employed by the Quinn Coal Company, subsidiary of Texasgulf, is recuperating well and back to work. The Hunters make their home in Cedaredge, CO.

'53 G. H. "Gerry' Bryant, E.M., and his family were recently able to combine business and pleasure when Gerry attended a uranium symposium in Australia. The meeting was held in the Northern Territory of Australia, where a large share of the world's known uranium reserves are located. Secretary-Treasurer of the Wyoming Mining Association is **Edward F. Ziolkowski, E.M.,** senior vice president of Energy Development Company.

'54 James Mulryan, E.M., recently underwent a double arterial bypass, corrective heart surgery in Los Angeles, California. The operation has been successful and he will soon be returning to part-time execution of his duties as Director, Safety and Land Development for Cyprus Mines in Montana. **Paul V. "Ron" Bethurum, P.E.,** is vice president of soda ash production for Texasgulf Chemical Co., Granger, Wyoming. In addition to his professional duties, Ron is active in the Wyoming Mining Association, serving as a director.

'55 Roland G. Hessell, P.R.E., is now manager, Asphalt Sales, East and South for AMOCO Oil Co., headquartered in Marietta, Georgia.

'58 Newly promoted from manager, Hard Rock Minerals to Vice President of General Crude Oil Co. is **William C. Bagby, BSc. Pet. David L. Waring** has been appointed manager of North American ore sales for The Hanna Mining Co., which he joined in 1964. He was most recently senior ore sales representative.

'59 Gordon L. Steele, Geol.E., is new operations manager of the Candelaria Silver Operations, OxyMin, Hawthorne, Nevada. The facility is planned to start mining operations late next summer. Prior to joining OxyMin, Steele was mining superintendent for Homestake Mining Co. in Gunnison, Colorado.

'61 Howard P. Christiansen, Met.E., has been appointed superintendent of rail accessories, mining and cutting edge mills for CF&I Steel Corp. He has been with the pioneer steel firm since 1964, when he joined the company as a technical supervisor in the research department, and has held a number of supervisory posts in the organization.

Thomas LaFehr

'62 Richard Richards, Geol.E., is now President of Fugro Rocky Mt. Inc., headquartered in Denver. The firm specializes in services to the mining industry. **Dr. Thomas LaFehr, Geol.E.,** and **Robert W. Hawkinson,** Belden Corp. president, have announced the sale of Exploration Data Consultants of Lakewood. Dr. LaFehr, chairman of Edcon, says the firm will operate as a wholly owned subsidiary of Belden, continuing its specialty of downhole exploration electronic and computer locations.

'63 James W. Gustafson, E.M., is now with International Salt Company. Mine Superintendent of the Belle Ayr mine, AMAX Coal Company, is **Harold Bailey, E.M.** He moved to Belle Ayr in early 1979 after a stint as operations manager for Cordero mine. **Ronald W. Clifton, Geol.E.,** is now Supervisory Civil Engineer, Water and Power Resource Service, U.S. Government, based in Lake Havasu City, Arizona.

John Lindemann

'64 Bruce Hersey, Met.E., is now metallurgical lab supervisor at Ethicon, Inc. in Somerville, N.J. **John W. Lindemann, Geol.E.,** associated with the Barringer group of companies, has been promoted to Chief Staff Geologist, Denver office. Lindemann, who has had extensive experience in many areas of the world, and has planned and executed major exploration programs, will continue to be based in Colorado. He is active in the CSMAA Denver Section activities.

'65 Raymond D. Zook, MSc. Met.E is Works Metallurgist for the ARMCO Inc. installation in Kansas City, MO.

'66 Daniel Witkowsky, Met.E., is now in Denver, where he is metallurgical engineer in the Intermountain Field Operations Center, U.S. Bureau of Mines. **Michael A. Rogalski, Met.E.,** has been promoted from Sr. Engineer to Technical Manager, Engineering Services, major projects for Shell Oil, in Benicia, CA.

'67 David Bolin, Geol.E., now occupies the position of specialists engineer with the Golden, CO office of Golder and Associates. His responsibilities include world-wide exploration activities coordinated from this office.

'68 David T. Berlin, P.E., is located in Odessa, TX, where he is District Manager of Engineering for Gulf Oil E&P Co.

'70 Fred E. Staible, BSc. CPR, who was formerly precommissioning service head for El Paso LNG Service Co., is now plant engineering service head for the same firm. **Gail Batman, CPR,** is now with Sigmor Refining Co., where he is employed as a process engineer in Three Rivers, TX.

'72 Oscar B. Nair, MSc. Math, is now associated with Golder & Associates in the Golden, CO office. **Steven Emerson, BSc. Met.,** is technical superintendent of the Stauffer Chemical Co., assuming the post September 1 in Wyoming.

'73 Mark Mathews, Ph.D. Geop., is now assistant group leader, geological applications group, at the Los Alamos Scientific Laboratory, Los Alamos, N.M. **Donna R. Messer, BSc. Geol.,** has recently changed jobs and is now employed by Texas Gas Exploration Corp., where she is a geologist.

'75 John E. Joseph, BSc. Geol., formerly with Tenneco, is now production manager for Fremont Energy Corporation. The new assistant superintendcent at the Emery Coal Mine, Emery, Utah, is **Steve M. Jaccaud, BSc. Min.**

'76 Steven M. Montagne, BSc. Met., is wire division metallurgist with Leggett & Platt. He lives in Carthage, MO. **Rene R. St. Pierre, BSc. Pet.,** is a new member of the engineering staff of Champlin Petroleum in Rock Springs, WY.

'78 Patricia M. Smith, BSc. Min., was married in June to Cecil Farnsworth. She has been promoted from junior engineer to mine engineer for the Orchard Valley Mine, Westmoreland Coal Co., Paonia, CO. **Judy L. Anderson, BSc. CPR,** is with Ashland Synthetic Fuels, Inc., where she works as a chemical engineer, in Huntington, WV.

'79 Sonia S. Knapp, BSc. Geol., is now in Corpus Christi, TX, where she is a geologist with the U.S.G.S. Office of Marine Geology. **Michael N. Norred, BSC. Min.,** who is employed by Fluor Mining and Metals, San Mateo, CA, was promoted in October to mining engineer/analyst.

in memoriam

Emeritus Professor Paul Bartunek

Dr. Paul F. Bartunek, professor emeritus of physics at Colorado School of Mines, died Thursday, Dec. 27 at the Georgian House in Lakewood after a long illness. He was 76.

A memorial service will be held at a future date.

Bartunek joined the CSM faculty in 1950 and retired in 1969. A native of Nebraska, he earned his bachelor's and master's degrees from the University of Nebraska and his Ph.D. in physics in 1935 from the University of Michigan.

Before moving to Golden, he taught at Massachusetts Institute of Technology, the University of Michigan, Renssalaer Polytechnic Institute, Lehigh University and the University of Maryland.

He was a member of a number of professional societies and served during the early 1960s as regional counselor in Colorado with the American Association of Physics Teachers and the American Institute of Physics. Bartunek worked to improve the quality of high school physics teaching in Colorado.

He and his wife Rachel were active in the Golden community, where he served for 12 years as treasurer of the Golden Civic Orchestra Association. Mrs. Bartunek died in 1969.

His body was cremated.

Danforth Barney

Danforth Barney E.M. 1942, died June 13, 1979 of cancer in Vancouver, Washington. He had made his home in Vancouver since retiring in 1968 from the Alcoa company.

Born in Ft. Schyler, N.Y. in 1905, Barney moved when young to Denver, where he graduated from East High School.

After working in various places in the U.S., Danforth Barney ended his career in Australia, where he spent over five years with Alcoa. He was a quality assurance manager for Alcoa at the Geelong, Victoria installation of that company.

While at Mines, he was a member of Tau Beta Pi and Sigma Alpha Epsilon. A life-long interest, amateur radio, led him to membership in the Quarter Century Wireless Association, in which he held a fifty-year membership.

Surviving are his wife, Helen H. Barney, a son, Dr. John S. Barney, two stepsons, Thoms W. Sylvester E.M. 1969 and Scott M. Sylvester, his sister Mrs. William Warren and one grandson.

Edward W. Luthy

Edward Luthy E.M. 1950, was deceased in 1976, according to information lately received at CSMAA. At the time of his death, his home was in Ft. Myers, Florida.

Luthy held a degree in civil engineering obtained from Tulane University prior to his attendance at Mines. He worked variously as a mining engineer and civil engineer following graduation.

Alton F. Conrad, Jr.

Alton Conrad E.M. 1932, died recently in Trout Lake, Michigan, where he made his home after retirement.

Conrad, born in Ohio in 1906, attended Case School of Applied Science before entering Mines. He worked for a time for the City of Cleveland after graduation, then as a construction engineer for a number of companies and the U.S. Government.

Mr. Conrad is survived by his wife and two children.

Karl H. Schmidt

Karl Schmidt Geol. E. 1936, died on November 4, 1979 in San Antonio, Texas. Mr. Schmidt was a consultant in the petroleum industry at the time of his death.

Following graduation, Schmidt worked for several petroleum companies and the U.S. Bureau of Mines in Wyoming. He later became an independent consultant.

He was married and the father of two children.

under the "M"

Amoco Foundation Teaching Awards

PURPOSE

To recognize superior teaching at the undergraduate level and to provide encouragement and incentive for teaching achievement.

AWARDS

Each year three (3) teaching awards of $1,000 each are made available to CSM from the Amoco Production Company.

CRITERIA FOR AWARD

1. Is the professor challenging to the students and does he install interest in his courses? Does he express interest as well as install it?
2. Does the professor motivate the student to think for himself?
3. Does the instructor establish rapport with the student?
4. Is his technical ability and knowledge reflected in the course?
5. Has he ability to present an interesting and informative lecture?
6. Does he instill a sense of professionalism, integrity and responsibility into the students?
7. Why do you think he is an outstanding teacher?
8. In comparison with your other teachers, why is he outstanding and the others not?
9. What is his availability to students?

ELIGIBILITY

All full-time professors at Mines with primary emphasis on undergraduate teaching. Recipients who received this award in the preceeding three (3) years are not eligible and include:

1976-77

George T. Bator, Mining Engineering (Deceased)

Oded Rudawsky, Mineral Economics

Robert D. Witters, Chemistry & Geochemistry

1977-78

Samuel B. Romberger, Geology

E. Dendy Sloan, Jr., Chemical and Petroleum-Refining Engineering

1978-79

Stephen R. Daniel, Chemistry & Geochemistry

David K. Matlock, Metallurgical Engineering

Nominating Letters

Nominations are encouraged from undergraduate and graduate students, alumni, and faculty members. Adequate detail is urged in the letter to provide sufficient information for the judging of candidates. One sentence concerning the persons teaching ability is not enough. Letters for judging are to be submitted to Dr. Wm. Mueller, V.P. for Academic Affairs by March 1, 1980.

General Education for Engineers

If engineers had raised practical questions when first warned about the impending energy crisis 23 years ago, instead of relying on "technological habit," a Colorado School of Mines professor writes, the nation's present energy shortage could have been avoided.

Dr. Peter Hartley, a cultural ecologist in the humanities and social sciences department at Mines, examines the necessity for engineers to consider social effects of technology in the current Mineral & Energy Resources, formerly Mineral Industries Bulletin (Vol. 22 No. 4)

"We had warnings over 23 years ago and could easily have stretched our domestic oil supplies enough so that we could have had alternative technologies," Hartley notes. Engineers ignored the forecast, he said, because they were not able to even imagine the "faint possibility" of another different technical solution.

In the article, "Interdisciplinary Education and Engineering," Hartley says that a superior general education for engineers is essential given the profound effect that technology has on society.

In schools such as Mines, which require a very rigorous engineering curriculum, Hartley says that liberal arts studies should give a basic knowledge for continued study after graduation.

Interdisciplinary education for engineers has been the subject of continued study at Mines as the school tries to define and prepare a program to educate the "engineer of the future."

Copies of the bulletin, published bimonthly by Colorado School of Mines Press, are available for $2.50 each. Full-year subscriptions are $10. Send checks to Colorado School of Mines, Publications Department, Golden, Colorado 80401 or call (303) 279-0300 Ext. 2607 for more information.

Energy Field Institute Wins Award

Janice Hepworth, left, project director, and Chuck Morris, CSM director of public relations, show off the Gold Pick Award for public service.

The second energy field institute, a program sponsored by the Colorado School of Mines to give Congressional and executive aides a firsthand look at Western energy, was awarded a Gold Pick Award from the Colorado Chapter of the Public Relations Society of America. The award was given for the most outstanding public relations work in the field of non-profit public affairs for 1979.

Janice Hepworth, project director, and Chuck Morris, CSM public relations director, accepted the award Dec. 11 at a reception at the Denver Press Club.

Members of the society's New Mexico chapter judged the program nominations enlisted from the Colorado chapter for the annual contest.

The institute was cited for its use of public relations techniques in planning and conducting the annual tour of energy sites in Colorado, Wyoming and Montana. This past summer 36 aides who work as energy specialists for Congressional committees, executive departments and federal agencies took part in the week-long program. Local media in the three-state tour covered the institute participants as they viewed coal, uranium, oil and gas, and oil shale operations.

WAAIME Scholarship Applications

Students working for degrees in engineering science within the minerals field (mining, geology, metallurgy, petroleum, mineral science, materials science, mining economics) who can show financial need, are eligible to apply for up to $1,000 from the Scholarship Loan Fund of the Woman's Auxiliary to the American Institute of Mining, Metallurgical, and Petroleum Engineers. The scholarship is 50% grant and 50% loan, the loan portion to be repaid within ten years of graduation.

Both graduate and undergraduate students are invited to apply now for awards for the academic semester beginning Fall, 1980. The deadline is **March 1, 1980.**

Applicants may telephone Mrs. Bruce (Monica) Peers, 986-0851, or may write to her at 948 S. Alkire Street, Lakewood, CO 80228. Persons applying must have first contacted their school's financial aid office. For undergraduates, preference is given seniors, juniors, sophomores, in that order.

Students applying for the WAAIME scholarships will be interviewed by the Denver committee which includes, in addition to Mrs. Peers, the chairman, mesdames Donald Donner, Dale Kittel, Willard Puffett, and Joseph White, Jr. Their recommendations and supporting papers must be provided to the national office by March 5, 1980.

Orediggers Named to All-RMAC Football Team

Two members of Colorado School of Mines' 6-4 football team were named first team All-Rocky Mountain Athletic Conference (RMAC) and first team All-NAIA District 7 in balloting announced recently.

In addition, four Orediggers were selected for second team RMAC honors and eight more received honorable mention. The players were honored at the team's football banquet Thursday, December 6.

Tight end Tom Netzel, a 6-3 200-pound junior from Longmont, and defensive lineman Mike McKenty, a 6-3 244-pound defensive lineman from Dearborn Heights, Mich., were named first team All-Conference and All-District 7.

Netzel, who received second team RMAC honors last year, caught 42 passes this year for 536 yards and two touchdowns. He averaged 54 yards a game and almost 13 yards a catch.

McKenty, a repeater from last year's first tam, was credited this year with 59 tackles, 31 assists, 5 pass deflections, 5 quarterback sacks and 2 fumble recoveries.

Named to the second team this year were quarterback Chuck VanAllen, fullback John Claussen, defensive back and return specialist Ron Powell (selected in both positions), and free safety Dennis Jelden.

VanAllen, a 6-2, 190-pound senior from Lompoc, Calif., led the RMAC in passing this year with a 155-yard-per-game average, and he added another 21 yards a game rushing for a total offensive effort of 177 yards a game. He was reponsible for 1,766 total yards on the season.

Clausen, a 6-2, 220-pound senior from Steamboat Springs, rushed 62 times this year for 235 yards, an output of 3.8 yards per carry. Powell, a 5-10, 182-pound senior from Golden, returned 18 punts this year for 169 yards, a 9.4 yard average, and he returned 13 kickoffs for 290 yards, an average of 22.3 yards.

As a defensive back, he was responsible for 39 tackles, 27 assists, 3 interceptions, 12 pass deflections and 2 fumble recoveries.

Jelden, the team's leading tackler and kicker, is a 6-4, 193-poiund senior from Greeley. He was reponsible for 66 tackles, 38 assists, 2 interceptions and 7 pass deflections.

Football Players Honored

CSM quarterback Chuck VanAllen and free safety-kicker Dennis Jelden were voted co-captains of the 1979 football team by their fellow players. The honors, based on leadership qualities demonstrated throughout the season, were announced Thursday, Dec. 6 at the team's annual banquet.

VanAllen was also named most valuable player and outstanding offensive player, while Jelden received the Tom Mead Spirit Award. Lineman Mike McKenty was named outstanding defensive player, and center Kevin Hammerly received the outstanding freshman honor.

VanAllen finished his two-year career at Mines by leading the Orediggers to a 6-4 season, their best record since 1975. A second-team All-Rocky Mountain Athletic Conference (RMAC) selection, the 6-2, 190-pound Lompoc, Calif., senior led the conference in passing with a 155-yard-per-game average.

His 10-game total offensive effort was 1,766 yards. He passed for 11 touchdowns and ran for 3 more during the year.

Jelden, the team's leading tackler, was credited with 66 tackles, 38 assists, 2 interceptions and 7 pass deflections on the year. In addition, the 6-4, 193-pound senior from Greeley kicked 4 field goals during the year and converted on 18 of 23 points-after-touchdown.

McKenty, a first team All-RMAC selection, was credited this year with 59 tackles, 31 assists, 5 pass deflections, 5 quarterback sacks and 2 fumble recoveries. The 6-3, 244-pound Dearborn Heights, Mich., senior received the outstanding defensive player award for the second year.

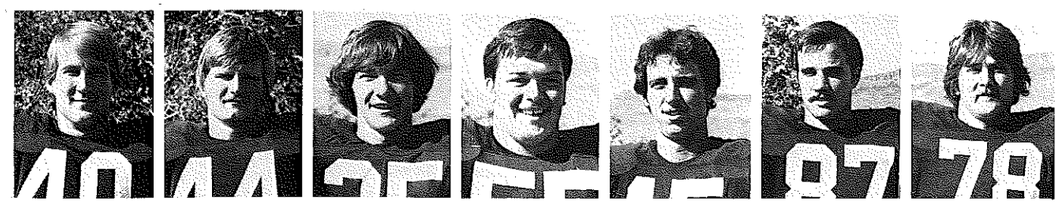
Hamerly, a 6-0, 250-pound freshman from Edgewater, received honorable mention in RMAC balloting this year.

In compiling their best record in four years, the Orediggers ranked third in the conference with a 5-3 RMAC record at season's end. The team was third in scoring defense (14.6 points a game), first in passing defense (108.6 yards a game), second in passing offense (173.6 yards a game) and third in total offense (324 yards a game).

In addition to the award winners, sophomore Dan Murphy ranked third in receiving with a 55-yard game average and senior return specialist Jim Mahoney ranked first in punt returns with a 12.8 yard average.

Orediggers named to the honorable mention team were:

- Dan Murphy, sophomore wide receiver.
- Steve Kearney, sophomore offensive lineman.
- Kevin Hammerly, freshman center.
- Mitch Knapton, junior tailback.
- Rick James, senior linebacker.
- Jim Mahoney, senior defensive back and punt returner.
- Kevin Patterson, senior defensive lineman.
- Foster Beckett, junior defensive lineman.



L. to R.: Jelden, Claussen, Powell, Hammerly, VanAllen, Netzel and McKenty.

Resource Education

by Jeff Freed

The Office of Resource Education (ORE) was created in 1978 by the Dean of the Graduate School of Colorado School of Mines to help inform women, minority groups, and others of the career opportunities available to Colorado School of Mines graduates in the mineral engineering field. Now, under the auspices of the Office of Admissions, ORE serves as a liason between the technical expertise of Mines, the educational community, and the community at large.

ORE is active in many areas to achieve the goal of publicizing mineral engineering careers. One of the focal points is public schools. It is important to reach children in the early grades in order to foster interest in the sciences. ORE has received many accolades for its work with the public school system. For example, one administrator writes "Experience throughout the country has indicated that exposure to engineering needs to be integrated into the school curriculum, and that carefully designed programs of career exploration need to be used to interest young people in the study of engineering. The ORE program at the Colorado School of Mines is the only program in Colorado which attempts to explain mineral engineering and science to school-age children. ORE is providing a valuable service by strengthening earth science and energy-related science curricula in the schools."

The Office of Resource Education also participates in various school career days by providing informational materials which point out the many advantages of pursuing a science oriented career. In addition, ORE pilot tests whole science teaching units for use in the K-12 school curriculum. Public school teachers benefit from in-service courses sponsored by the Office of Resource Education to upgrade their science educational methods. As Cass Sanger, District Science Specialist for Adams County Schools, says of one of the Pre-College Teacher Development courses sponspored by ORE "We particularly needed and benefited from the NSF Pre-College Teacher Development courses. They were most valuable in bringing us up to date on the latest trends in science and engineering."

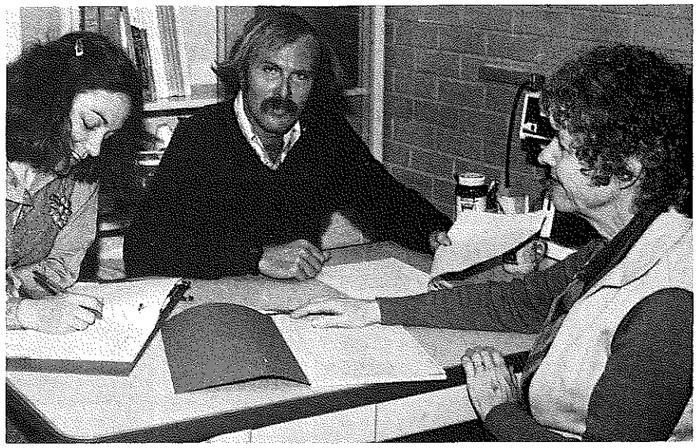
ORE is very active on the Mines campus in terms of setting up workshops for Mines students, working with women and minority groups on campus, and in aiding the Office of Adminssions in its recruitment efforts. One of the unique functions of the Office of Resource Education is its ability to fill the role of facilitator between CSM students and industry as evidenced by the ongoing series of workshops presented for students by ORE, the Placement Office, the Student Activities Office on Career Choice and Development, and the CSM Alumni ofice.These workshops have featured speakers from industry who gave practical advice to the students on job seeking and career management. Students at Mines are faced with a bewildering array of career possibilities and decisions particularly in this time of tremendous energy development. They need the help of programs like these workshops to aid them in making these decisions and becoming better and more satisfied employees. Industry will benefit as well from having these CSM graduate employees who have begun early on to think of career management. In addition, the Office of Resource Education, in cooperation with Dr. Betty Cannon's Technical Writing class, has designed a series of pamphlets for Dr. Cannon's students to write for mineral engineering recruitment purposes. These writing projects include such subjects as "How to Choose an Engineering School" and "Preparing for a Plant Visit". These reports will be extremely valuable to students considering Mines and also to CSM students preparing to enter the working world.

ORE assists the Office of Admissions by revising and updating the CSM Bulletin and by designing counselor learning packets for dissemination to school counselors. These packets encourage students to focus their thinking on possible entry into science or engineering careers.

The Office of Resource Education also works as a consultant for private industry. It has designed and may sell a unique hands-on science learning project for use in the schools called "What's Happening with Energy in Your Home." The project is designed to teach students about electricity and energy conservation. Jim Donlin, Educational Specialist for Public Service Company, which will distribute the project, said of ORE, "The Office of Resource Education is in the best possible position to assist high school students in the choice of careers in the various fields of engineering. Public Service Company of Colorado feels the continued support for the ORE critical, if enough engineering students are to be graduated to meet the technological needs of the next decade."

The Office of Resource Education coordinates resource people within the Mines community and the Denver metro area as a natural outgrowth of its ongoing contacts with both the private and public sectors, and these contacts have helped make ORE an invaluable resource center for may diverse groups seeking speakers and people of expertise in various fields. These lists of contacts are, of course, open to anyone on campus who would wish to use them.

ORE welcomes inquiries: Call or write Room #413/Paul Meyer Hall, CSM, 303/279-0300, ext. 2896.



Annette Adler, Jeff Freed and Jeanne Brenimer engage in a planning session at a regular ORE staff meeting.

CSM Students in "Who's Who"

Thirty-seven students from the Colorado School of Mines have been selected to appear in the 1979-80 edition of "Who's Who Among Students in American Universities and Colleges".

The Mines students were selected by campus nominating committees and editors of the annual directory base on the students' academic achievement, service to the community, leadership in extracurricular activities and future potential.

Students are selected for listing in the edition from more than 1,200 colleges and universities in the U.S. and several foreign nations. Outstanding students have been honored in the annual publication since it was first published in 1934.

Mines students named this year include Ravel Ammerman, Timothy Barbari, Leonard Brammeier, Julie Bryant, Michael Cusick, Amy Dall, Brian Damkroger, Frank DeLuca and David DeSonier.

Also named were Collin Fay, Gary Gasser, David Gilbronson, Paul Giusti, Erik Goodwin, David Holligan, Gerald Kelton, Gregory Larrabee, James Mahoney and Gary Milstein.

Also included were Timothy Mower, Kenneth Neumann, James Oldani, Heide Pattee, Richard Pattee, Richard Peters, Timothy Popp, Ronald Pratt, George Shapre, Layne Shilling, Garon Smith, Steven Smith, Sandy Stash, Ralph Tolson, Steven Wheeler, Richard Williamson, Matilda Wilson and Jonathan Worstell.

Problem of Exponential Growth

Often forgotten in the "optimistically erroneous" material on the nation's energy crisis are simple mathematical equations that point to the danger of exponential growth in population and energy consumption, according to an article in the most recent edition of the Colorado School of Mines Mineral and Energy Resources (Vol. 22 No. 5).

Albert A. Bartlett, professor of physics at the University of Colorado in Boulder, compares the problem of exponential demand for fossil fuels to the rapid reproduction rate of bacteria. With the repeated doublings characterized by such growth, Bartlett writes, a few such doublings can lead to enormous demand in very short time.

In "Forgotten Fundamentals of the Energy Crisis," Bartlett urges that the reader be aware of the difference between "authoritative reassuring" statements from the media on the energy situation and the results of "simple calculations."

Rubin Named to Resources Communication Center

Bob Rubin, a former KOA manager of operations and radio programming and sports announcer, has been named director of the Resources Communication Center at the Colorado School of Mines.

Rubin, a Denver native and 1955 graduate of the University of Denver, was employed at the KOA stations for 8½ years before coming to Mines.

In his new position, Rubin will direct the production of videotape programs to explain mineral resources and development, particularly in Colorado and the Rocky Mountain area.

He succeeds Dr. Albert Burke, the former director of the two-year-old Resources Communication Center, who has resigned.

Decker Resigns

Betty C. Decker of the CSM Alumni Association staff has resigned after 19 years of service with the Association.

Mrs. Decker has not indicated her plans for the future. She will continue to live at 1220 17th Street, Golden, in the house near the Mines campus which she has rented from the School of Mines for a number of years.

Well known to many Mines alumni, Mrs. Decker has been very active in campus and community activities. Mrs. Decker is the Blue Key advisor, having been the first woman elected to that honorary service fraternity. She is an honorary member of the CSM Alumni Association, having been elected in 1978.

I am looking for a name for this column—I toyed with the idea of calling it "Behind Bev Mason's Filing Cabinets," since that's *really* where my office is located. That seemd to lack a bit of dignity, so I thought about such things as "Perspective," "My View," "From My Vinecovered, Pigeon-haunted Window," or "Looking Across the Commons." Thus far, nothing has caught my fancy, so this will be an untitled opus—no. 1.

The beginning of a semester is always exciting—and nerve-racking for the students or friends of students who've just gotten their grades. I've been encouraged by the number of people who've come in to chat with smiles instead of frowns and groans. Maybe they're working harder, maybe they're caught up in the general feeling of urgency in the extractive engineering fields—whatever the reason, it's nice to see them back and ready to take this semester's challenges. Physics, strengths and fluids have even been conquered by some I know!

It's also the beginning of a new year for the Alumni Association. We will be functioning under a new Board of Directors in February, and looking forward to a good year in 1980. I'd like to wish them all a successful year in managing a growing and interesting organization.

We're hearing a lot, here in Colorado, about the development of oil shale and its prospects for taking up some of the slack in the darkening import picture. One of the facts that may not be fully understood is the dearth of good *miners* . . . not mining engineers, although the supply is not abundant here, either, but people willing to work as miners. What has happened to the supply of people interested in this job? Have our increasing emphases on the easier, service-oriented jobs driven them away, or have they perceived the mining industry, because of adverse press it too often receives, as being an undesirable workplace? Oil shale development will not only be the only area affected by this—the coal mines are suffering, also.

President Carter proposed, in his energy bill recommendations, that 1.5 to 2.0 million barrels a day of "new" fuel could be generated in oil shale or coal conversion to offset the 4.5 million barrels he wished to stop importing. We are nearly as far from reaching that goal this upcoming spring as we were when it was first proposed last spring.

One of the reasons has to do with the lack of trained people, or people willing to be trained. Another reason, with which we are all too familiar, is the lack of committment by the Federal government (and in some cases, State governments), to loosen the untoward regulations on the energy industry. If workers view the industry as one with little future, because of regulatory restraints and negative publicity, who is to blame?

I'm seeing students, soon to be engineers, eager, working hard, and struggling with the technical aspects of their professions . . . all with a view toward going to work. It seems to me I also see, along with a lot of empty rhetoric, a paralysis in governmental policies which should be providing these people and others with an opportunity to solve our problems.

Patricia Curtis Petty

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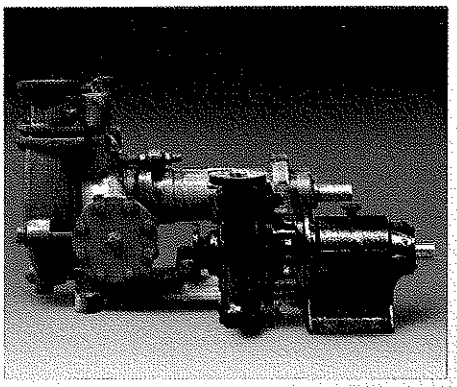

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