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The Obelisk: Revisited

J. TERRY ENGELDER

Depoliticizing Energy: The Lessons of Desert Storm

RICHARD L. GORDON

PENNSTATE

1855

BIRTHDAY WISHES

On the occasion of his eightieth birthday, we pay tribute to former EMS Dean Elburt F. Osborn, who in the course of an illustrious career has had a significant influence on the development of the College and the University.

Appointed in 1946 to head the Earth Sciences Division in the then School of Mineral Industries, Dr. Osborn became the first in the United States to hold the academic title 'professor of geochemistry'. He served as Dean of the School from 1953 to 1959 and as Penn State's Vice President for Research until 1970, when he became Director of the U.S. Bureau of Mines. In 1973, Dr. Osborn resigned from government service to accept the post of the Carnegie Institution's first Distinguished Professor, at the Geophysical Laboratory in Washington, D.C. He retired as Distinguished Professor Emeritus in 1977.

While at Penn State, Dr. Osborn attracted a series of outstandingly talented students and substantial financial support. In a remarkably short time, he established what became an internationally renowned research group in experimental high temperature and high pressure studies in geosciences and materials. Sparked by his leadership, Penn State geosciences expanded its graduate program and flourished—only fifteen years after granting the first doctoral degree in 1951, the geosciences graduate program was ranked as 8th in the nation. During Dean Osborn's tenure, EMS witnessed a dramatic increase in research funding, particularly from government sources, and a concomitant increase in numbers of graduate students. When he was Vice President, the pattern repeated and there was a fourfold increase in Penn State's research funds.

As a scientist with broad research interests ranging from oxide and fluoride systems to magmas and blast furnace slags, Dr. Osborn became a proponent of interdisciplinary research. As Vice President for Research, he became the 'father' of formalized interdisciplinary research groups and facilities throughout the University, nurturing the establishment of the Institute for Research on Land and Water Resources, the Pennsylvania Transportation Institute, the Ordnance Research Laboratory, the Computation Center, and many others.

While a member of the Penn State faculty, he set the standard for his active interest in national scientific policy issues, and served as advisor to the National Science Foundation, National Research Council, Congress and many other agencies. He has been president of the Mineralogical Society of America, the American Ceramic Society, the Society of Economic Geologists and the American Geophysical Union. His honors range from elected membership in the National Academy of Engineering, and Honorary Doctor of Science degrees from Alfred University, DePauw University, Northwestern University and Ohio State University, to prestigious awards such as MSA's Roebling Medal, ACerS's Jeppson Award and Bleininger Medal, and the Hardinge Award of AIME.

In October, large numbers of Dr. Osborn's colleagues, friends and admirers gathered at Penn State to honor him. At the Osborn Symposium, his former students, now themselves distinguished scientists and academics, spoke of the profound influence "Ozzie" has had on their research, their lives, and their careers.

We're sure Bulletin readers will wish to join with us in saying, "Thank you, Ozzie. Many Happy Returns!"

John A. Dutton

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The Obelisk: Revisited

J. Terry Engelder
Professor of Geosciences

The obelisk was erected near the Armory, one of the campus's major buildings. Regrettably, it was razed in 1964 to make room for the extension to Willard Building.

To my knowledge, no man-made structure in the world serves better to illustrate the overall effects of continental drift on mountain building and the sedimentary record than the Penn State obelisk.

With the exception of the limestone statue of the Nittany Lion near Recreation Hall, very few landmarks on the Penn State campus are as noteworthy as the 33-foot-tall stone obelisk a few dozen yards southwest of Old Main. The obelisk was erected in 1896, under the supervision of the first dean of the School of Mines and professor of mining engineering and geology, Magnus H. Ihlseng, for the purpose of measuring the rate at which building stones crumble when subjected to central Pennsylvania weather. Ihlseng collected 281 stone blocks from stone quarries throughout the Commonwealth of Pennsylvania. Curiously, a few stones from Massachusetts, New York, Ohio, and England were also placed in the monument. At the time, stone was being used extensively in the construction of such buildings as Old Main and there was general interest within the construction industry concerning its long-term resistance to weathering.

Fifty-three years after the construction of the obelisk, John Eliot Allen, professor of geology, evaluated the extent of crumbling and weathering of each stone block and described his findings in an article that appeared in *Mineral Industries* (March, 1949), the predecessor to *Earth and Mineral Sciences*. Using petrographic examination of thin sections from each block, Prof. Allen compared his findings with predictions made in a 1899 B.S. thesis by William L. Affelder for resistance to the elements. Combining Affelder's and Allen's scores, the largest block in the obelisk, a bluish conglomerate found three-quarters of the way to the top, earns highest rating as a building stone.

One feature, which makes the obelisk of great interest to the geologist, is the arrangement of various stones according to their age with oldest at the base. Notable exceptions to this rule are that all crystalline rocks,[a] igneous and metamorphic, are located below sedimentary rocks regardless of their age, and the base of the obelisk is the same bluish-gray conglomerate as the largest block found three-quarters of the way to the top. The age of the rocks varies from approximately 1.1 billion years, a gneiss near the base of the obelisk, to about 180 Ma (Ma = millions of years ago; My = a period of millions of years) for several blocks of diabase, an igneous rock surrounding the gneiss near the base. Between the age of the gneiss and diabase are all of Pennsylvania's sedimentary rocks. These sedimentary rocks constitute a detailed record of the history of a mountain belt, the Appalachian Mountains. This record is remarkable in that many of the famous mountain belts of the world such as the Alps, the Rockies, the Himalayas, and Urals all have a similar history of sequential events, although occurring at different times in the Earth's development.

Looking toward the present location of the College of Earth and Mineral Sciences soon after construction of the monument.

The history of a mountain belt is best understood in terms of plate tectonics, a theory which grew from the discovery of continental drift. When Ihlseng erected the obelisk, he, like all contemporary scientists, was unaware of continental drift and could not possible have known that the obelisk was a wonderful monument to the theory of plate tectonics.[b] To my knowledge, no man-made structure in the world serves better to illustrate the overall effects of continental drift on mountain building and the sedimentary record than the Penn State obelisk. This is because the large variety of Pennsylvania building stones that make up the monument represent many of the important geological events affecting the Appalachian Mountains during the past billion years, Figure 1.

The various stages of both continental drift and mountain building are part of a cycle of continental rifting, separation, convergence, and collision now called the Wilson Cycle. For the Appalachian Mountains of Pennsylvania, this cycle starts during a period when most of the continental area of the Earth was gathered into one vast supercontinent. Supercontinents form with the collision and suturing of several small continental masses as these continents are swept together into one large land mass. The 1.1-billion-year-old gneiss toward the base of the obelisk contains a deformational fabric developed as a consequence of the assembly of a Late Precambrian supercontinent. Eventually such supercontinents are unstable, and later divide or rift into half a dozen smaller continents, as is found on the Earth today.

The oldest sedimentary rock represented is the Potsdam Sandstone[c] near the base of the monument. In the obelisk, this sandstone marks the start of the Wilson Cycle that ultimately led to the Appalachian Mountains surrounding the University Park campus. Sometime between 650 and 550 Ma, the Late Precambrian supercontinent started to break up, with the formation of rift valleys much like those found in Africa today in the vicinity of Lake Victoria. Such continental rifts fill relatively quickly with sediments derived from nearby mountains. As the rifts widen, the ocean invades the rift valley much as the present Red Sea separates the African continent from the Arabian shield. The Potsdam Sandstone is a beach sand, similar to those found at the edge of the Red Sea

As the pieces of the Late Precambrian supercontinent cor ued to drift further apart, major ocean basins filled the sp between the smaller continents. This stage of the Wilson Cyc called the drift stage. At that time, Pennsylvania was at the so western edge of a continent we call Laurentia which was bord by an ocean named Iapetus, Figure 2. Laurentia eventually bec the core of the North American continent, whereas the Iap Ocean was a Paleozoic predecessor to the Atlantic Ocean anc this reason is also called the "Proto Atlantic." At this time N Europe was a minor continent within Iapetus. Other smaller l masses within Iapetus included New England, Nova Scotia, Scotland. For a period between 530 and 480 Ma, the Pennsylvai edge of Laurentia resembled the Bahama banks, for it was loc near the equator where shallow tropical seas favored the growt massive carbonate banks. Around the State College area, tl carbonate banks grew to exceed 2 km in thickness over a perio about 40 My. Blocks from these carbonate banks were placed ir lower third of the obelisk, Figure 1. Some of these stones are m of those building stones that veneer Old Main and Univer House (the old President's house) near Deike Building.

As was the case of the Iapetus Ocean, ocean basins dc grow indefinitely because lithospheric plates of cc nental and oceanic crust move on the the surface of a sphere, asthenosphere of the Earth, rather than on a flat plane. Eventu the ocean crust of one lithospheric plate starts to be consumed subduction zone, where continents or island arcs of another li spheric plate move over the ocean crust. At about 480 Ma, the oc crust attached to Laurentia started riding down a subduction z which had developed within Iapetus Ocean crust. By analogy, present Indian Ocean crust is riding under the Indonesian island and the northeast Pacific Ocean crust is moving under the Aleu island arc.[d]

As this ancient island arc moved toward Laurentia, f grained sediments (the Martinsburg Shale) were shed from island arc to cover the vast carbonate banks of Pennsylvania. ancient island arc eventually collided with Laurentia to form Taconic Mountain range along the edge of the Laurentian cc nent. Some marbles in the lower part of the obelisk are the remn of the carbonate bank after it was heated, deformed, and metan

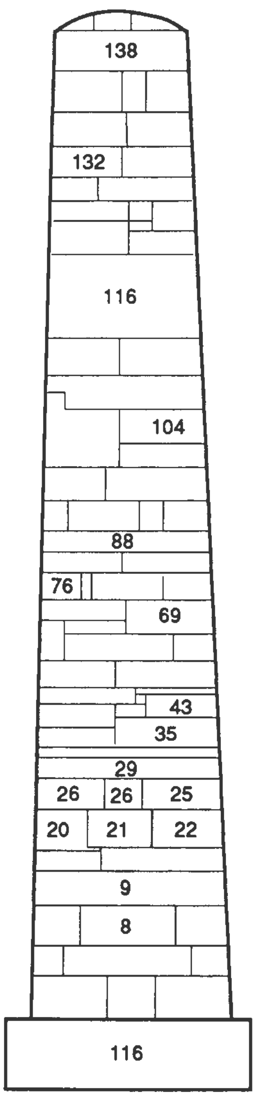

Figure 1. The obelisk's west side charts the formation of Pennsylvania.

Block Number	Formation Name	Age (Ma.)	Comments
138	Newark Ss.	230	Breakup of the Pangaean supercontinent
132	Allegheny Ss.	310-290	Deposition of Pennsylvania coal measures
116	Pottsville Cg.	310	Formation of Pangaean supercontinent
104	Mauch Chunck Ss.	320	Denotes onset of the Alleghanian Orogeny
88	Flagstone	360	Deposited during erosion of Acadian Mtns.
76	Devonshire Sl.	370	Signals uplift of Acadian Mts. near England
69	Tully Ls.	380	Carbonate banks after erosion of Taconics
43	Tuscarora Ss.	420	Taconic Mts. in final stages of erosion
35	Bald Eagle Ss.	430	Taconic Mountains start to erode
29	Martinsburg Sl.	440	Island arc forms on southwest of Laurentia
20-26	Ls. & Dol.	530-480	Bahama-like carbonate banks of Laurentia
9	Potsdam Ss.	540	Supercontinent begins to fragment
8	Gneiss	1,100	Piece of Late Precambrian supercontinent

Block numbers as assigned by J.E. Allen (1949); Ss. = Sandstone, Cg. = Conglomerate, Sl. = Slate Ls. = Limestone, Dol. = Dolomite.

phosed deep within the Taconic Mountains. Likewise, the Martinsburg Shale was metamorphosed to become the slate seen in the obelisk. As is the case along present mountain ranges such as the Andes and Himalayas, the tops and flanks of ancient mountain ranges were subjected to severe weather conditions, which caused rapid erosion with thick piles of sediment deposited adjacent to the mountain range. The Bald Eagle and Tuscarora Sandstones of the obelisk mark the rapid erosion of the Taconic Mountain Range in less than 10 My.

Even as the Taconic Mountains were reduced by erosion, a segment of the Iapetus Ocean still lay to the south of Laurentia. For a period between 430 and 390 Ma the southern edge of Laurentia was again a stable continental shelf where carbonate banks, small coral reefs, and salt flats developed. Because salt is useless as a building stone, the thick salt beds deposited at about 420 Ma in northwestern Pennsylvania are not present within the obelisk. One carbonate representative of this period is the Tully Limestone, deposited at 380 Ma. By this time, North Europe, including the crust that later became England, swept against Laurentia as the lithospheric plates, consisting of both Laurentia and Iapetus, pivoted counterclockwise. Gondwana, the largest remaining piece of the Late Precambrian supercontinent, had moved from an equatorial position to the south pole of the Earth, Figure 3.

By 390 Ma, the southern margin of Laurentia was starting to show signs that it was a subduction zone, with Iapetus Ocean crust sliding under the large continent. This subduction zone was characterized by large magmatic intrusions and the uplift of the Acadian Mountains in the area of New England. Perhaps the Andean Mountain chain of South America is the best modern analogue to the Acadian Mountains of New England. Like the Taconic Mountains, the Acadians were rapidly attacked by weathering and erosion, and a large sedimentary pile called the Catskill Delta was deposited on the southern edge of Laurentia in the vicinity of Pennsylvania. Contemporaneous clastic deposits formed on the English portion of the Laurentian margin. One block of the obelisk from England comes from this period when England and Pennsylvania shared the same margin of Laurentia. The organically rich sediments of the Catskill Delta were the source rocks for much of Pennsylvania's rich crude oil. A thin slab of Pennsylvania "flagstone" of the Catskill

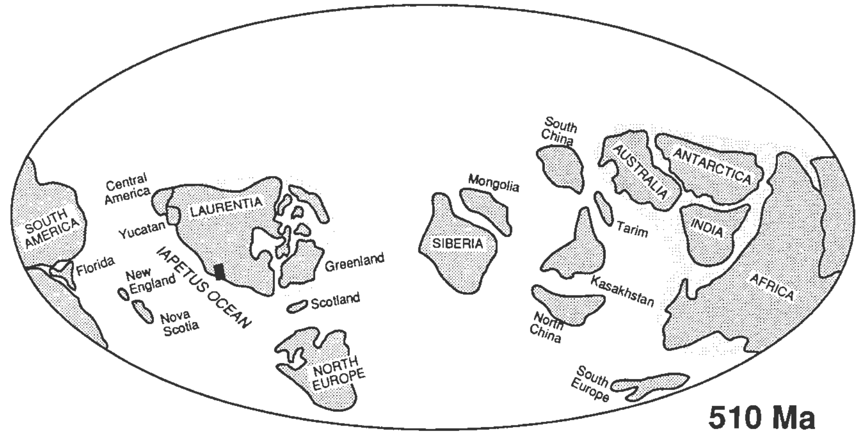

Figure 2. The position of continents on the surface of the Earth shortly after the breakup of the Late Precambrian supercontinent at about 510 Ma. Major continents are identified by capital letters. Minor land masses are identified by lower-case letters. The continental masses of Africa, Antarctica, Australia, India, and South America are assembled in a large continent called Gondwana. At the time, Pennsylvania was located on the southwestern margin of Laurentia (black rectangle). Figures 2, 3, and 4 adapted from Scorese (1984).

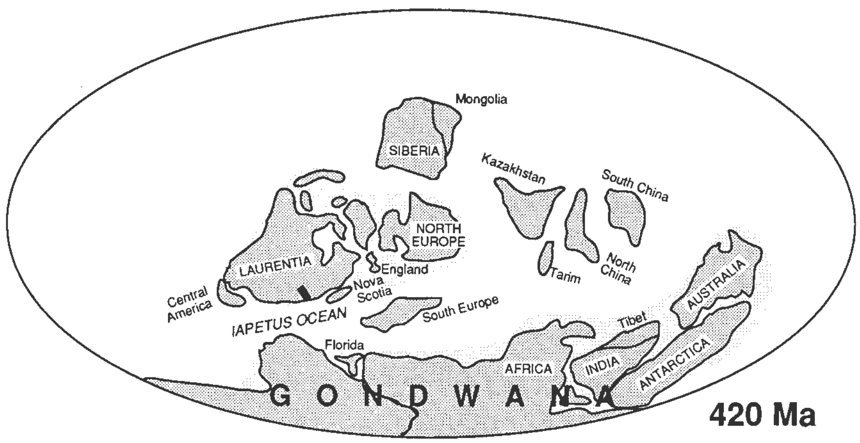

Figure 3. The position of continents on the surface of the Earth shortly after Gondwana had drifted to the south pole of the Earth at about 420 Ma. At the time, Pennsylvania was located near the equator on the southern margin of Laurentia (black rectangle).

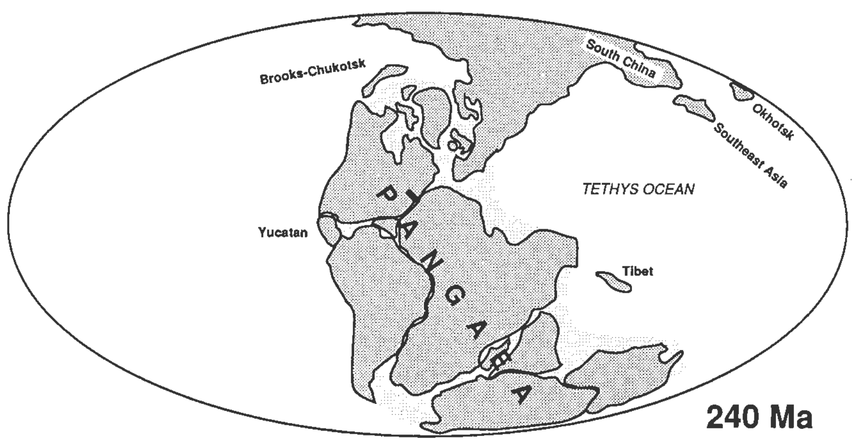

Figure 4. The position of continents on the surface of the Earth at the time of the formation of the Pangaean supercontinent at about 240 Ma. At the time Pennsylvania was located on the equator and well inside the Pangaean supercontinent (black rectangle).

Delta, dating from about 365 Ma, neatly divides the upper and lower halves of the obelisk. To this day, such flagstones are used for sidewalks and fireplace mantles throughout Pennsylvania.

As subduction of the Iapetus Ocean progressed, Gondwana (a collection of the present day continents of South America, Africa, India, Antarctica, and Australia) was converging upon Laurentia from the south. The collision of Gondwana and Laurentia produced tremendous deformation on both sides of the suture between these two large land masses. With the suture of Laurentia and Gondwana, another supercontinent called Pangaea had formed, Figure 4. At this point, some 300 My had passed since the breakup of the Late Precambrian supercontinent. Deformation during this later suturing, called the Alleghanian Orogeny, was relatively rapid and produced the present Appalachian Mountains.

Much of the upper half of the obelisk consists of sandstones deposited on Pennsylvania during the period of about 100 My when it was part of the Pangaean supercontinent and when the Appalachians were being eroded, as in the previous mountainous phases. The Alleghanian Orogeny was complex and had several deformational pulses. Two such pulses are marked by the deposition of the Mauch Chunk Sandstone and the Pottsville Conglomerate found in the upper part of the obelisk. A block of Pottsville Conglomerate was used for the base of the monument and another block of this rock is the largest single piece found above the base.

As erosion of the Appalachian Mountains slowed, large swampy lowlands covered much of Pennsylvania. These swamps were rich in fallen tree trunks and leaves which, when buried under other sedimentary rocks, became coal. Sandstones from the Pennsylvania coal measures comprise a portion of the upper fifth of the obelisk. By 280 Ma, the Alleghanian Orogeny reached a culmination with the massive thrusting and folding of rocks in cen Pennsylvania. Some coal measures are wrapped up in the foldi particularly within the anthracite district of eastern Pennsylvai Nittany Mountain is a syncline formed at this time within the ou reaches of the Appalachian valley and ridge district. The culmi tion of the Alleghanian Orogeny brings to a close a Wilson Cy during which the Iapetus Ocean formed with the rifting of the L Precambrian supercontinent and ceased to exist with the creatio Pangaea from the collision between Gondwana and Laurentia.

An early view toward the Old Engineering Building on College Avenue.

By 230 Ma, the break up of the Pangaean supercontinent started in earnest. The top of the obelisk consists of Newark Gr sandstones that mark the start of another Wilson Cycle. New Group sandstones were deposited in rift basins, again much those of central Africa. During this rifting event, the continent Africa and North America emerged in their present shapes. ocean that eventually filled the rift basins of the Newark Grou the beginning of the Atlantic Ocean.

In a sense, the sedimentary rocks of the obelisk span period between the break up of the last two supercontinents to e on the face of the Earth. The next supercontinent lies perhaps My ahead, for we are presently in a period between the assembl supercontinents. Thus, the obelisk, a monument which is so m a part of the Penn State scene that students and faculty pass it d on the Mall without a second thought, reveals a tremendous hist and that history can be read by geologists much like reading record set down in the books of Pattee Library.

Endnotes

[a]At the time there was no way to absolutely date crystalline rocks, theories said that they must be older than sedimentary rocks.

[b]The theory of plate tectonics states that the upper layer of the Earth, lithosphere, is divided into a number of plates that continously slide the interior of the Earth, the asthenosphere.

[c]While this block of sandstone came from the Adirondack Mountain New York, sandstones of equivalent age and geological setting in Penn vania are called the Chickies Quartzite or Antietam Quartzite dependin location within the state.

[d]An island arc develops because the subducted ocean crust melts as heated within the Earth.This melt, magma, often flows back to the surf to form a long string of large volcanoes that make an island arc.

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J. Terry Engelder was an undergraduate at Penn State, and becan member of the faculty in 1985. He presently teaches courses in r mechanics and structural geology. He is currently a principal investig for a major study of the formation of pressure compartments, sponsore the Gas Research Institute, and he has just finished writing a book Princeton Press entitled *Stress Regimes in the Lithosphere*. Engelder been a Fulbright Scholar (1984) and was elected as a Fellow of Geological Society of America in 1989.

Depoliticizing Energy: The Lessons of Desert Storm

RICHARD L. GORDON
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Micasu Fellow of Mineral Economics

The Iraqi conquest of Kuwait and its impacts confirmed well-established criticisms of worldwide political mismanagement in energy. For at least most of the twentieth century, extensive political concerns have prevailed on energy and particularly on crude oil. Many observers believe that oil markets cannot function without government assistance because oil is unique. In contrast, the economic literature on oil argues that government intervention in the industry was unwise. An extensive dismal record has accumulated.

Uniqueness is not a useful criterion for intervention. The nature of all commodities is that they have features making them distinct. Few such characteristics justify government intervention, and oil lacks such attributes.

Free markets for energy would be preferable. Politicization causes rather than solves problems. Government policy should be directed at relentlessly reducing the scope of interference and promoting a commercial approach to the industries.

Both theory and practice support this argument. Economics is devoted to persuading nonspecialists that their fears are unfounded. Economists like competitive markets—ones with the prevalence of an attitude of rivalry, where participants compete to outperform others, rather than joining in plots to rig the market, or begging the government to do so. These conclusions are reached using far more care than the critics are willing to acknowledge. Those inconvenienced by economic arguments like to contend that economists concentrate on the virtues of unregulated markets, yet economic theory actually deals extensively with the breakdowns as well as the virtues of markets, and with the cases for and against government intervention. The theory suggests and observation dramatically confirms that intervention in oil is likely to be harmful.

The wrong interest groups always influence regulation. Whatever their faults (and these have been grossly exaggerated by industry critics), private companies have compiled an impressive record of finding, developing, and providing on a steady basis, large supplies of oil and natural gas. The rulers of Middle Eastern countries may pontificate on their right to secure the income of their national oil patrimony, but the much-told history of world oil shows how the predecessor rulers had to be coaxed and paid (openly as well as through whatever covert action may also have occurred) to permit operations to proceed. In one famous case, the Sauds demanded a shift from profit sharing to a fixed per-barrel payment because of doubts that the profits would amount to anything.

Government policy should be directed at relentlessly reducing the scope of interference and promoting a commercial approach to the industries

Conversely, the record of government action is universally depressing. The United States, Western Europe, Japan, Australia, and South Africa have consistently pursued policies harmful to national welfare. Nothing seems to shake this tendency. The 1991 U.S. *National Energy Strategy* well illustrates this. The report begins by asserting that stress will be on "continuing the successful policy of market reliance." The proposed implementation involves acceptance of many dubious criticisms of the market, timid proposals to lessen a few obviously defective interferences, praise for many others, and proposals for extensions.

Countries such as those in the Middle East that produce oil predominantly for export have protected their national interests well at our expense. In particular, they have tried to restrict supplies and increase oil prices at the expense of importers around the world. The experience is part of the classic role-of-government debate and specifically an example of the problem of not being adequately concerned about government interference with markets. Adam Smith well characterized the case in 1776:

"...every individual necessarily labours to render the annual revenue to render the annual revenue of the society as great as he can. He generally, indeed, neither intends to promote the publick interest, nor knows how much he is promoting it . . .[H]e intends only his own gain, and in this, as in many other cases. led by an invisible hand to promote an end which was no part of his intention . . .By pursuing his own interest he frequently promotes that of the society more effectually than when he really intends to promote it. I have never known much good done by those who affected to trade for the publick good..."

Since these words appeared, much has been written on their meaning. Defenders suggest that what people best can do is master their specialties and try to sell their services to others. The world is too complex for anyone to understand: thus individuals are incapable of comprehending the broader implications of their actions and cannot know what is the public good, nor affect to trade for it. The implication is that the best approach is to ensure that everyone concentrates on competing as effectively as possible. Following the advice of W.S.Gilbert, the Victorian librettist, politicians should not interfere with things they cannot understand.

Smith and his successors were well aware that much, and probably most, of the criticism of these arguments arises from the relentlessness of competing to promote gain. People fail, and immediately run to government for protection. Since no one likes to admit failure, elaborate excuses are fabricated. These days, they can be developed by misusing those economic theories that indicate where intervention is desirable.

Some attackers however are motivated by what is fundamentally an elitist disdain for a commercial society that elevates pursuit of individual interests over allegedly nobler pursuits such as of (in those days) empire. This apparently was true of Carlyle's dismissal of economics as "the dismal science." (While Adam Smith is widely reprinted, Carlyle is hard to find. His phrase lives on only from what often must be 100th-hand repetition. I can only claim to have read several people who have actually read Carlyle.)

Broad attacks on government currently emanating from many sources reflect the severe defects of intervention. The dismissal of the critics as extremists is an evasion; it recalls the old joke about the speaker (identified, as expedient, as a politician, a lawyer, a preacher, an economist, or whosoever the teller wishes to disparage) who writes a marginal reminder—"weak point, shout a lot." Energy defects are enough to cover here. Readers can decide for themselves whether generalization is as appropriate as I claim.

Oil policy is the quintessence of the alliance of snobs and protectionists. For many decades, a battle has raged between those who believe the best approach is to foster a commercial outlook and those advocating intergovernmental management of supply. Increasing the politicization of oil was a clear disaster. As argued below, the security of supply argument for intervention reverses the truth.

The prior description of competition implies that its attainment eliminates problems; that is, if lots of people are struggling for business, none can afford to interfere with the flow of commerce. With sufficiently vigorous competition, no one source matters enough for its disruption to affect markets. (Ronald Coase won the 1991 Nobel Prize in economics for his careful analysis of the comparative strengths and weaknesses of markets and government. He began with a forceful statement of the advantages of competition. He added that the frictions that limit competition also hamper government action. Under many circumstances, intervention will worsen the situation.) Of course, disruptions will arise from natural and manmade disasters. In a competitive, flexible, unfettered world, such disturbances will have small impacts in both size and duration. Efforts will be made by the direct victims and their rivals to restore supplies rapidly. Consider, for example, how fast the lost output of Kuwait and Iraq was replaced in 1990. Moreover, so long as the threat of intervention does not interfere, prudence will cause potential victims to prepare to offset crises. One clear illustration is the U.S. coal market, where strikes have been a regular feature for decades. The disruption is never harmful overall because users stock up to meet the crisis. Politicians argue, and many energy economists agree, that this argument does not apply to oil. However, oil companies are typically larger and stronger than the electric utilities that are the main coal users, and the fact that oil crises are rarer and less predictable lessens the need for inventories as well as lessening the incentives. But the main barrier to pr oil inventory holding is the political attacks on profiteering arise in every oil crisis. Oil companies fear that they cannot p from their prudence. The institution of a public stockpile to c the lack of private inventories is an unsatisfactory reaction: it treats symptoms. Fears of windfalls retard release. The disruptions, for example, inspired only token releases.

Intervention is excused by assertions about the lack of c petition prevailing in world oil. The members of the Organiz of Petroleum Exporting Countries (OPEC) do try to limit com tion, and this can, among other things, aggravate the impac disasters. This possibility may justify some countermeasures they should be very different from actual policies.

Where competition is weak, disruptions can promote fu weakening. The oil shocks of the seventies showed the m could at least temporarily bear prices far above what even the avaricious producers believed. OPEC countries quietly mainta supply restrictions to perpetuate the high prices; some critics the countries publicly most committed to maintaining suppli practice undertook the greatest cutbacks. The oil actions were successful than price rigging efforts in other industries (and ea ones in oil). However, the net effect of gyrations since 197 been that 1991 prices exceed those of 1974 by less than the ri world price levels. The 1986 price war brought constant d prices under their 1974 level, and subsequent regrouping fail restore the 1974 level—and left prices well below the peak l 1980.

However, this situation arose only because consuming c tries pursued policies to encourage collusion among the C countries. Public policy in the United States and other cour systematically thwarted competition and encouraged politiciza Dismantling the policies that produced this outcome is by fa most effective way to increase competition and alleviate crises process previously mentioned of the interaction of protectio with contempt for commercialism operated continually and v ously.

Major consuming countries affect competition in basic ways—through how they influence dom production and consumption, through policies toward energy other countries, and through influence on energy policies in countries. The U.S. has erred in all three realms, but most e rately and ruinously with domestic energy. A primary cau difficulties was discouragement of the emergence of a compe foreign oil industry by policies to protect domestic energy pro ers in the United States, Western Europe, and Japan.

The problem was aggravated by faith among foreign m tries that the best policy was an effort to ensure oil flows by pol influence. What produced this belief is hard to determine. writings of the apologists fail to satisfy even such elem requirements as consistency—the same writer, facing new dence, would radically alter his appraisals without acknowle the change. It is unclear whether the arguments were believe merely stated to disguise the need to capitulate to protecti pressures. If the beliefs were sincere, they were unrealistic confused. It has never been clear whether the goal was t political means to ensure oil supplies, or to sacrifice oil suppli other foreign policy goals such as lessening the influence c Soviet Union. Neither approach is workable and all evic suggests that trying to ensure oil supplies by political arrangen with other countries is neither wise nor effective. Countries w the end stress money: they will tax to the limit possible, they will expand or contract sales as the economic climate justifies. Nothing—not political favors, not military support, not installation of a company domiciled in your country—can prevent this.

No one will want to exploit the alleged advantage of operating in an oil-exporting country. That country will object to losses to favoritism. The company will develop worldwide interests such that it no longer can afford to give its home country special treatment. A country powerful enough to influence an oil exporter will also have oil-using allies with which it will feel compelled to share oil.

Conversely, the bribe of more oil money is unlikely to buy much. Even governments that persist pursue their visions of self-interest and many governments have fallen in such countries. Such falls do not by themselves harm oil supplies since the successors are at least as anxious to receive oil revenues. The Iraqi revolutions of the fifties and sixties interfered with supply expansion but never disrupted existing supplies. Qadaffi of Libya is a living parody of the much-maligned concept of economic man: he promotes terrorism by maximizing oil profits and spending the proceeds.

The best that can be done is provide open markets and display a willingness to deal predominantly on a purely commercial basis. This cannot guarantee that no cartels will arise, but it is better than trade restrictions and favoritism. Both are competition-lessening. The absence of open markets clearly created the prevailing restraints on competition: removal of protectionism will encourage more competition. This is a no-lose policy with a non-negligible prospect for producing large gains.

The contrast between the virtues of free markets and the continual political thwartings is also well-explained by economic analysis. Protection produces widely scattered small losses and large gains to a few. These few care more than losers and are those heard in political debates, and thus a powerful expensive-energy lobby exists around the world. The least surprising participants are the producers of expensive energy. The most visible and least important are the large oil companies. Small oil and gas producers in the United States and coal mine labor in the U.S., Japan, and Western Europe have been the most effective influence, and they are joined by promoters of other sources, such as fuel from grain. Given the love of foreign ministries for managing oil, they have been cheerleaders of the expensive-energy movement. The environmental movement's unrelenting opposition to all energy supply expansion options has made it another powerful portion of the expensive-energy coalition.The long record of energy policies in the United States, Western Europe and Japan amply confirms these statements. Here an overview of U.S. experience will suffice.

Extensive government involvement began no later than with the energy aspects of World War I mobilization. This was the start of the largely producer-oriented phase of expensive-energy policy that lasted until 1974, when rising anti-producer attitudes in Congress reversed policy directions without eliminating the bias toward high costs. An unpublicized achievement of the Reagan administration was to dismantle much of this new apparatus; the Bush administration started by removing another obstacle. (This made Reagan the first president since the start of government intervention in energy to take pro-competitive steps.) To sustain the first era, the U.S. restricted imports: to sustain the second, the U.S. (despite claims to the contrary) encouraged imports.

The critical aspect of the old era was state oil-production control. The controls were imposed to resolve the problem associated with the tendency of oil and gas fields to extend over the properties of many individuals. The fields are interrelated systems, hence each should be operated on a coordinated basis, but formidable problems arise in getting the individuals to agree on a coordinated program. The question of how best to effect this remains controversial, however, it is widely agreed that pressure on private parties to agree is preferable to the government assumption of control that actually arose. State controls worked so badly that even those operating them moved to promote private cooperation. The only remaining controversy about the private solution is how best to attain it. Some argue for active government pressures; others suggest that all that is necessary is refraining from interference with private actions.

In any case, a combination of administrative convenience and political expediency created a class of numerous "small" unregulated producers. (As often is true in such cases, small was quite different from poor: the people could be quite wealthy.) Resources heavily entered this sector. State regulators succumbed to enormous pressures to restrict activities of low-cost producers enough to allow survival of a large number of exempt high-cost producers. With the rise of extensive oil supplies abroad, import competition threatened to sweep away these high-cost producers. Surrounded by cant about promoting national security, pressures were exerted to limit imports. As often occurs, the efforts began by warning oil companies that if they did not restrain their imports, the government would.

Refuting the charges that oil companies monopolize the U.S. market, their competition caused them to take advantage of the availability of cheap foreign oil. In 1957, the government made its last effort at voluntary compliance by setting up explicit import restriction goals it wanted enforced. Again competition prevented attainment. The government imposed explicit restrictions in 1959. From the start, the program was plagued by controversy. A quota system was employed: quota holders could buy at the world price and resell at the higher protected U.S. price. Given the profits involved, continuous maneuvering for access to quotas prevailed. The states that were clearly victims, most of those on the East Coast, sought loosening of controls. By the end of the Johnson administration in 1968, it had become clear that a radical change was needed.

However, given Johnson's problems with opposition to the Viet Nam war and his reputation as an oil industry supporter, he chose to defer to his successor. That successor, Richard Nixon made a brilliant start at solution in 1969 but ultimately proved unwilling to act effectively. Nixon ordered what proved to be the best study any government ever made of oil programs: a particularly able staff was assembled; opinions were secured from all the interested parties, including domestic and foreign energy producers and some large-scale energy users; leading outside experts were consulted. The study argues that at a minimum, the system should be radically streamlined. It was further suggested that our best hope was making the U.S. market more open to imports and thus encourage competition for our markets among foreign producers. Nixon, apparently because he was more concerned with assuaging oil interests in Texas, left the old system in place. Only with the 1973-4 oil price shocks, that might otherwise not have occurred, did Nixon abandon import control.

This policy of protectionism increased rather than decreased the instability of imported energy supplies. In the presence of import controls in the U.S., Europe and Japan, the inherent incentives to fight to capture the main markets of the world were blunted. Concern shifted to getting a higher price for what you were allowed to sell. Particularly strong evidence here is the major role Venezuela, a country heavily dependent on U.S. markets, took in forming OPEC. This action occurred only after requests for greater access to the U.S. market were rebuffed.

Moreover, several observers of world oil markets suggest that Nixon administration officials interfered in oil company-OPEC negotiations in a fashion that unleashed the price shocks. In particular, in 1971 a new Undersecretary of State, guided by the arrogant career diplomat whose inconsistent writings were those noted above, undercut oil company efforts to resist oil country pressures to raise prices. The initial defense by that career diplomat was that this tactic reduced the size of inevitable price increases. His critics warned that in fact the price increases were avoidable and were probably the first step in movement to much higher levels. The latter of course proved true. The defenders of intervention might counter that they at least slowed things down: again, conclusive proof is impossible. Nevertheless a policy that at best delayed an undesirable outcome and may have caused such an outcome was worse than doing nothing. This is only the most important part of a story that includes much more and continues to evolve.

Another major pre-1973 policy was to grant tax favors to oil and gas producers, and later to all mineral producers. The one dissonant note was the imposition of price controls on natural gas in 1954—this arose from problems of interpreting an earlier (1938) law governing natural gas and was another political misstep. The 1938 act was apparently designed to regulate pipelines, but ambiguities were such that assertions were made that well-head prices of gas also were covered. Without judging whether such extension was desirable, the Supreme Court interpreted the law to cover field prices. Congressional efforts to avoid this were twice vetoed—first by Truman on ideological grounds and then by Eisenhower in over-reaction to dubious lobbying tactics of the gas industry. At this point, Congress gave up and left us saddled with undesirable and unworkable controls on gas.

The post-1973 era started with Nixon imposing temporary controls on the price of oil produced in the U.S. that various subsequent extensions allowed to last until the start of the Reagan administration in 1981. The Ford and Carter administrations extended the restraints. Carter, looking at the close division about how to deal with the problem of natural gas price control, chose to tilt in favor of making the controls tighter and more explicit. It took until the Bush administration to reverse this decision. Carter also added taxes on oil production to oil price controls; these were eliminated in the Reagan administration. Both the new gas price controls and the oil taxes perpetuated the expensive energy bias: low-cost producers were penalized by lower gas price ceilings and higher oil taxes than high-cost producers.

Numerous controls on energy consumption—auto fuel-efficiency standards, requirements for appliance standards, and a totally ineffective effort to force utilities and industry to use more coal—were also legislated in the Ford and Carter years. Except for boiler fuel controls, these persist. The 1991 National Energy Strategy displays inordinate fondness for much of this consumption management.

Another development was an obsession with windfall profits on federal oil, gas, and coal leases. The states have become obsessed with windfall profits in electric utilities and probably are unduly discouraging investment.

The case for environmental action is so often and uncrit stated it needs no repetition. Given the numerous groups inv and their biases, some excesses probably occurred. The rest on offshore oil and gas are the most clear cut. The alternative imports, and tanker spills are more prevalent than offshore dents. While even the impacts of tanker accidents are less th publicity suggests, they still exceed those from offshore acci

Even the criticisms of nuclear power and coal may have excessive. The attacks on nuclear power based on routine rele radiation, plant accidents, and release of radioactive mate rouge governments and private terrorists proved largely in Concern centers on "safe" storage of wastes: the waste pr may be more political than scientific.

The existing regulations on coal pollution may reflect tive appraisal of the risks. The rationale for the 1990 tighten sulfur and nitrogen oxide pollution reduction goals was v misreported. The publicized damages of acid rain to lake forests were far too small to justify the costs of implementi 1990 legislation. Additional benefits were claimed and the was on improving health. However, prior legislation supp was already moving the U.S. toward the desirable level of improvement and subsequent research has suggested that the legislation was based on exaggerated estimates of the healt efits of reducing air pollution. It is not apparent that offsetting were made in appraising the ability of the prior goals to produ desired results.

In sum, more barriers than justified have been plac energy development. This mass of dubious policies then evidence of needlessly weakening the functioning of energ duction and use in the United States. This dismal record su that everyone who can should intervene less. It is such a clima encourages the Sadam Husseins and necessitated Operation I Storm. As noted, contrary to fears at the time, this crisis h minute immediate oil market impacts. The outcome has pav way for a long period to at least 2010 of low oil prices—of barrel or less. Of course, this requires restraining the expe energy coalition.

Further Reading

Yergin, Daniel. *The Prize: The Epic Question for Oil Money and Power.* Ne Simon and Schuster, 1991. The latest but far from the best of ma histories. The sketchy coverage of the past 30 years lessens its ad over earlier works.

Adelman, M.A. *The World Petroleum Market.* Baltimore: Johns Hopkin 1972. This is the classic statement of the case that oil markets wor without intervention and that oil supplies are not nearing exhaustion the book uses little technical apparatus, the clipped style makes for reading. The forecasts on supply lived up to Adelman's claim estimates erred on the low side. His most recent work presently avai a series of articles and working papers indicates ample supplies will c over the foreseeable future.

Hartshorne, J.E. *Politics and World Oil Economics* (often cited by its Engl Oil Companies and Governments). While obviously very dated, it most thoughtful general book on oil.

Sampson, Anthony. *The Seven Sisters: The Great Oil Companies and the They Created.* Sampson is a careful reporter, a lively writer, antibusiness idealogue. The original edition contained a detailed acc the events of the early 1970s that created the present era of expensive Evidence from many other sources suggests that, whatever his intepre he is accurate and reasonably complete in his reporting.

A member of the EMS faculty since 1964, Richard L. Gordon is directo College's Center for Energy and Mineral Policy Research. He is author of nu books and monographs on energy topics and his research has been honore University, his profession, and the government of Venezuela.

CAM Celebrates Five Years

This summer, the College's Center for Advanced Materials celebrated its first five years of operation. Established in 1986 through major funding from the Gas Research Institute (GRI), Pennsylvania's Ben Franklin Program and the University, CAM was a unique venture for the College, specifically designed as a multidisciplinary unit to bridge the gap between university researchers and the industries involved in using and supplying materials designed for severe environments. Among the industries targeted to benefit from CAM research were high-temperature process industries such as glassmaking, metal heat-treating and coating, steelmaking, and aluminum, together with manufacturers of internal combustion engines.

Richard E. Tressler, then Section Chair of the Ceramics Science and Engineering Program in the Department of Materials Science and Engineering, was appointed as CAM's founding director. From the start, he sought to organize a balanced and energetic group of faculty and graduate students with complementary research interests who would work together across departmental and college boundaries to establish a center with a strong all-University Penn State identity. In this, he has achieved remarkable success. Participants in CAM's research projects are drawn from University programs in Ceramics, Polymers, Metals, Engineering Science and Mechanics, Mechanical Engineering, Civil Engineering, Chemical Engineering, and the Materials Research Laboratory and the Applied Research Laboratory. As Tressler and EMS Dean John A. Dutton intended, few if any outside the University identify CAM with the College of Earth and Mineral Sciences.

Bridging the gap between university and industry was an immediate challenge, involving both the translation of industry needs into university-style research projects and procedures and the transformation in faculty viewpoint from an academic to an industrial focus. The transition has been achieved smoothly through constant dialogue among CAM researchers and industry representatives and by formal annual reviews of CAM by all participants in the program.

The overall level of funding for the new center allowed a rational and workable organization: Tressler's role as director became a full-time position and Dr. John Hellman joined the faculty as assistant professor with part-time duties as associate director, while supporting staff members were added to handle administrative duties. An external advisory board with representation from industry, government and the industrial research community was appointed to address CAM's general direction; an internal advisory council oversees the operation for the College.

GRI and CAM

As befits its major investment, GRI's interest in CAM's development has been extensive during the initial years. In addition to the support of individual research projects, specific GRI funding was provided for technology assessment and transfer initiatives and for the establishment of an engineering and analytical services unit—functions that have added immeasurably to the viability of the center.

CAM has gained widespread visibility during its five years of operation through the *CAM Newsletter* and through a series of technology transfer sessions. Highlights have been a short course on *"Designing with Ceramics,"* workshops on *"Corrosion of Ceramics," "Indirect Heating Technology," "Tubular Ceramics,"* and *"Advanced Materials in Natural Gas Engines,"* and an international symposium on *"Corrosion and Degradation of Ceramics."* An additional project, with the National Institute of Standards and Technology, is the development of a Structural Ceramics Database that contains evaluated data on materials specifications, thermal and mechanical properties, and measurement methods in a DOS-based system.

As its name implies, the Engineering and Analytical Services unit concentrates on providing fast response to industry problems, particularly failure analysis, materials evaluation and characterization, and testing, verification and modeling of processes and procedures. Work has included such areas as ceramic radiant tubes, refractory feedstocks, heat exchangers, furnace hearth plates and composite component fabrication. Among the most extensive projects has been work on radiant tubes, where engineers were able to draw on theoretical and experimental research by CAM's project research group in identifying thermal shock and thermal cycling damage as life-limiting factors for ceramic radiant tubes. Additional sophisticated analysis is currently underway to characterize this thermal behavior. A further project has clarified the technology required for fabricating laminated silicon-carbide whisker-reinforced mullite tubes by a tape-winding process followed by hot isostatic pressing. An ongoing project is examining high-temperature composites with a view to developing models that predict a series of physical properties as a function of temperature and a range of microstructural parameters.

The major portion of GRI support has been the funding of an impressive series of basic and applied research projects that have added significantly to knowledge of the advanced materials designed for industries fueled by natural gas. Overall, 29 projects have been funded by GRI; they include:

- corrosion of nonoxide structural ceramics
- gas boosting of glass melting
- high-temperature corrosion-resistant metal-based material for gas fired systems

- the durability of nonoxide ceramics in simulated heat-treatment environments
- test methodology for tubular components
- performance verification for new low-cost ceramics
- wear mechanisms in structural ceramics
- chemical surface interactions
- mechanical properties of fibers
- fiber preform processing
- mechanical behavior of cellular ceramics
- infiltration of green or partially sintered ceramics
- physical property measurements of high-temperature composites.

Other CAM Initiatives

The Cooperative Program in High-Temperature Engineering Materials Research was initiated at the beginning of CAM's second year. Membership has grown steadily and CAM has attracted an impressive array of corporate sponsors. Members gain many benefits including significant access to center research through semiannual meetings conducted at Penn State. The Coop Program continues to be a highly successful means for diversifying the center's interests and sponsorship. Apart from administrative expenses, annual dues for corporate membership are used solely to support graduate assistants and their expenses as they pursue thesis research. Appropriate research topics are determined by consultation between faculty members and Coop members and reviewed by a Steering Committee consisting of one representative from each member organization. By June 1991, 28 students supported by CAM funding had received their graduate degrees.

In 1988, CAM was awarded $2.3 million in funding from NASA to carry out basic research required to prepare for a new generation of high-performance aircraft. NASA's goal is to develop lighter engines with greater stress resistance and higher performance characteristics than the metallic materials currently used in aircraft engines. Before such a goal can be realized, an enormous range of fundamental work must be carried out to characterize the properties and behavior of innovative composite systems. Working closely with scientists at NASA's Lewis Research Center, CAM researchers are investigating new reinforcing fibers, the detailed mechanics of various ceramic composites, and the interfacial behavior of metallic, intermetallic, and ceramic matrix composites.

Other industrially-sponsored research projects include work on corrosion and the degradation of composites and coatings, and projects on carbon-carbon composites. Research on continuous fiber ceramic composites is funded by the Department of Energy.

With the fifth anniversary of CAM, Richard Tressler relinquished his position as director and became head of the Department of Materials Science and Engineering, though he will remain actively involved with the center. He is well-satisfied with his tenure at CAM. Recently he commented, "We have created a viable research organization that is recognized nationally and internationally for its work on advanced materials in severe environments. We have accomplished a great deal in five years—I'm looking forward to the next five years as we broaden our scope and diversify our sponsorship. I believe CAM has an exciting future."

CAM's New Director

The future of CAM lies with its new director, Dr. Digby Macdonald, newly appointed professor of materials science and engineering. Dr. Macdonald has the diverse background ideally suited to leadership of a multidisciplinary research center. He is a New Zealander who carried out his doctoral work in chemistry at the University of Calgary as a National Research Council of Canada Scholar. He comes to Penn State from SRI International, where he was a senior metallurgist, Director of the Chemistry Laboratory from 1984-88, and subsequently Director of the Materials Research Laboratory and Deputy Director of the Physical Sciences Division. He has held positions with the Whiteshell Nuclear Research Establishment, Canada, the Department of Chemistry of Victoria University, Wellington, New Zealand, and the University of Calgary. From 1979 to 1984, he was professor of metallurgical engineering and Director of the Fontana Corrosion Center at Ohio State University. His research interests have focused on electrochemistry, corrosion science, chemical kinetics, solution chemistry and thermodynamics and he has published very extensively in these areas.

Digby D. Macdonald

As he looks to the future of CAM, he sees that ceramics, ceramic matrix composites, fibers, coating and high temperature materials will remain the cornerstone of the center's efforts because of the special expertise of the existing CAM faculty associates. The center will continue to build the fundamental knowledge base of how materials behave in extreme environments. However, he expects to add new thrust areas as opportunities occur, including a greater emphasis on corrosion science and engineering (including oxidation) and polymer science and engineering. These new areas will address important material problems in key sectors of the society, including both fossil and nuclear power generation and energy storage and conversion, particularly batteries and fuel cells.

In concert with these goals, Macdonald hopes to expand CAM's marketing efforts and develop more attractive mechanisms for interacting with industrial sponsors. He is currently reviewing all CAM's industrial programs, from single sponsor contracts to CAM fellowships for visiting scholars, to increase their effectiveness and ensure that this vibrant research organization will continue to make important contributions to technological advancement in the years ahead.

Geographers Learn in the Field in Jamaica

The undergraduate-graduate Seminar in Human Geography is usually a lively and intellectually fun class with a focus on environmental and development problems in a Third World setting; the actual topic changes each year depending on the interests of students and instructor. This year we were rather bored with theory and abstractions about the Third World and felt the need for something real and concrete we could experience for ourselves. The result was a spring seminar followed by a two-week field trip.

Selection of topic and destination were relatively easy—Jamaica. Knowledge of the area played a part but contacts were crucial, and here EMS and Penn State alumni were the deciding factor. Among them were Anne Lyew-Ayee, once an EMS geographer and now teaching at the University of the West Indies; her husband Parris, an EMS mining engineer and now Associate Director of Jamaica's Bauxite Institute; Gil de Campos, an EMS mineral economist and now a consultant for ALPART; and Andrew Dunbar ("Doc" to everyone around him), a Penn Stater from the College of Agriculture; and not forgetting Anke Wessels-Bayer, a current doctoral student of geography with two years of teaching experience in Kingston. Anke contacted the Sisters of the Immaculate Conception, who let us stay in one wing of their convent—and use the swimming pool. But for the arrival of a new geographer (Class of 2012?), Anke would have come too. Without this Penn State network, we could never have done it.

If the preliminary spring seminar taught us anything it was how little you could actually learn about Jamaica while sitting in the middle of Pennsylvania. The latest suburban atlas of Kingston, home for over half of Jamaica's population, was published in 1960 based on 1950s data, and the new national map sheets of Kingston just happened to be "out of print." Lots of historical stuff was available on the Spanish, slavery, British colonialism and so on, but not much about anything after Independence in 1967. We pieced together what background information we could, but the real answer was that we had to see for ourselves.

Based in Kingston, we spent long days in the field. The first, led by the University of the West Indies geographer David Miller, took us to the Blue Mountains to learn about their complex geology and geomorphology, and to see what the phrase "human impact on the physical environment" really means. The pressure of farming and tree cutting is already intense, and on steep slopes under heavy tropical rainfall the soil simply gives way. Slumping is common once vegetation is removed and the small feeder roads are frequently cut by landslides, isolating villages and preventing the famous Blue Mountain coffee and other agricultural products from reaching processing sites and the market.

And it was not just the impact of tropical downpours on the steep terrain of the Blue Mountains that taught us a lesson. At the end of the first week we had 11 inches of rain in 12 hours and saw for ourselves how a whole country can be cut apart, north to south, east to west, by floods. That evening we made it back to base from the north coast in our diesel van against a foot-deep stream which had been a main road just six hours before—by next morning the bridge we had crossed was broken by flood waters.

Bauxite and its reduction to alumina is a major industry and source of revenue for Jamaica. Thanks to our EMS alumni, we saw every step of the way, from clearing the valuable topsoil, through alumina reduction, to restoration of the mined areas. ALCAN's operations were particularly impressive. Mined areas are regraded to the bare white limestone, then the top soil is replaced and sown in coarse grasses to make lush meadows. The result is that ALCAN is now Jamaica's major producer of milk and beef, while emphasizing the former for nutritional input to the diets of children, rather than beefing up the patties for the local Burger Kings. To sustain such an undertaking, the breeders have concentrated on the Jamaica Hope, a hybrid whose cows show their Jersey heritage but whose massive bulls betray their Brahma forebearers. The result is a heat-tolerant animal that produces a calf each year (temperate breeds calve only every 18 months or more), so milk production is freshened regularly. The program is supported by the latest cryogenic methods to produce and preserve sperm for artificial insemination, a product exported around the tropical world.

Most farming is small scale, although a visit to a sugar factory and its adjacent rum distillery reminded us of the huge areas of sugar cane along the coastal plain and flat valleys that still feed these centuries-old industries. Small farms grow coffee all over the island, but only the best high-altitude growths are allowed the coveted Blue Mountain label. At Mavis Bank, the coffee production of 2,800 high-altitude small farms is collected and meticulously processed and graded. It forms the standard for the rest of the world's coffee production. About 90% of the Jamaican coffee industry is now supported by Japanese capital, a respected and appreciated source because it came

through when no one else would provide funding, and was generous after the devastation of Hurricane Gilbert. You can hire a pavilion in Tokyo today for yourself and three guests, where after a suitable "coffee ceremony" you can consume coffee at $100 per cup. In the United States it is "only" $19 per pound—without the ceremony, of course.

Cocoa is produced in the same way, mainly by small-scale farmers, who mix the trees with plantain and bananas for shade, and put scores of other food-producing crops in the "lower story." Until an agricultural expert like Andrew Dunbar takes you on a slow tour, you think you are walking through lush scrub growth. Then a dozen different food-producing trees are identified and the "weeds" turn out to be cassava, potatoes, yams, vegetables, all mixed together to form an agricultural system that sustains a family, produces crops for market, and keeps a cover on often fragile tropical soil. Before you can see, you have to know how to look.

But some things hit even the untrained observer in the face. An urban field trip with Anne Lyew-Ayee took us from the luxurious cantilevered homes of the district of Beverly Hills to the most abject poverty and squalor of squatter areas. It is through these poverty-stricken slums that the AIDS epidemic is spreading quickly. Many areas of old Kingston, down by the waterfront and harbor, are in a chronic state, and the old produce markets are now shunned by Jamaicans who used to buy there. Even armed police are reluctant to enter some of the worst areas. Political passions run high, and sprayed graffiti mark well-defined boundaries between neighborhoods. To cross from one to another you take your life in your hands. Kingston is a typical primate city of the Third World, a dominating spider sitting in the middle of the web, its bright lights drawing people into it. No one seems to know exactly what to do. Perhaps there are just too many people?

They were long, hot and tiring but enjoyable days for the twelve of us, and it will certainly take some months for us to absorb and think through all the lessons learned in that brief two-week period. For all those EMS and Penn State alumni connections in Jamaica, a heartfelt thanks for what you helped us to see and to learn.

Peter Gould
Evan Pugh Professor of Geography

ESSC Hosts EOS Workshop

The scientists involved in the College's Earth System Science Center make up one of the major interdisciplinary groups involved in "Mission to Planet Earth," NASA's central contribution to the U.S. Global Change Research Program. The NASA program consists of a series of satellites called Earth Probes and the Earth Observing System (EOS) which includes a space-based observing system, a data and information system, and a scientific research program.

With other research science groups across the country, the Penn State team is preparing for the first major EOS launch, scheduled for 1998. The Earth System Science Center's multi-million dollar project, titled the "Global Water Cycle: Extension Across the Earth Sciences," tackles some of the highest priority issues of the U.S. Global Change Research Program.

Much of the scientific planning for EOS takes place in science panels. As principal investigator of the Penn State team, I chair the Science Panel on Physical Climate and Hydrology and represent EOS scientists on the EOS Science Executive Committee.

This year, in July, the Panel on Physical Climate and Hydrology sponsored a four-day workshop at Penn State called "Science Foundations for the EOS Era: Physical Climate and Hydrology." This EOS conference replaced the successful series of summer workshops sponsored by the Earth System Science Center to bring together scientists developing the emerging discipline of earth system science.

Whereas much of the previous activity of the Panel on Physical Climate and Hydrology has involved only principal investigators and leaders of instrument teams and focused on the EOS program and planning, the main goal of this Penn State workshop was to promote scientific interaction and collaboration among EOS scientists. The workshop provided the first major opportunity for co-investigators and graduate students to participate within the wider EOS community, and more than 80 scientists attended, including 29 graduate students from across the United States. This widespread participation was made possible by special NASA funding for the workshop.

The five major themes for the meetings covered the role of clouds, surface hydrology, land/atmosphere/ocean energy fluxes, ocean/atmosphere/cryosphere interactions, global analyses, and the coupled climate system. Most sessions began with a keynote talk that provided a broader perspective on the scientific questions to be addressed by EOS. The vast majority of the session speakers presented current research results, much of them produced by the initiation of EOS funding. A total of 45 30-minute talks were given, many of them followed by lively discussion.

In addition, a special presentation on the World Climate Research Program's Global Water and Energy Experiment (GEWEX) was given by Michael Coughlin of the GEWEX Project Office to promote communication between scientists involved in the GEWEX activities and those focusing on the planned EOS physical climate and hydrology research.

The workshop also provided an ideal opportunity for a Science Panel meeting. Panel members reviewed their 40-page report on "EOS Science Priorities for Physical Climate and Hydrology: Key Measurements" that outlines the major issues and uncertainties, presents key objectives, and lists the critical measurements required to meet the EOS objectives. For each of the required observations, the report outlines the significance of the physical or biological variable, current measurement capabilities, and the contribution expected from EOS.

They also discussed future workshops and activities and were in full agreement that informal scientific meetings such as the Penn State workshop should be a regular activity for the panel and for EOS in general. Since our workshop was the first of its kind, it covered a wide range of topics. In the future, meetings will be more focused and rotate among different EOS institutions in order to maximize the involvement of investigators and graduate students. There will also be an effort to publish research contributions in special volumes. The topic proposed for the next EOS workshop is "major data sets for climate and hydrologic research."

Eric Barron
Director, ESSC

APLAN NAMED HONORARY MEMBER OF AIME

Frank F. Aplan, distinguished professor of metallurgy and mineral processing, has been elected an honorary member of the American Institute of Mining, Metallurgical and Petroleum Engineers. This is one of the highest honors the Institute can bestow, and is awarded to Aplan for "his innovative, prolific and productive career of outstanding contributions to the integration of theory and practice in the processing of coal, ores, and industrial minerals." Aplan was the only member of the 20,000-member Society of Mining, Metallurgy and Exploration to be selected for the honor this year.

ALLEY RECEIVES PACKARD FELLOWSHIP

Richard B. Alley, assistant professor of geosciences and faculty associate in the Earth System Science Center, has been awarded the David and Lucile Packard Foundation Fellowship in Science and Engineering for 1991. This is the second major award he has received in the past two years. In 1990 he was awarded as a Presidential Young Investigator.

Alley is a glaciologist whose research focuses primarily on ice sheet processes and the identification and interpretation of glacial signals of past and present global climate change. He is a member of the Siple Coast Project in Antarctica and the Greenland Ice Sheet Project II, and for several years has been involved in working groups advising the National Science Foundation and NASA on aspects of Antarctic and Arctic glaciology.

The Packard Award is much sought after among young scientists and engineers since it provides a total of one-half-million dollars in research support over a period of five years. This is the second Packard Fellowship to be won by Penn State faculty members—both to members of the Department of Geosciences. **Susan L. Brantley**, associate professor of geosciences, received the Packard Fellowship in 1988—she too is a Presidential Young Investigator.

MESSING NAMED PARTICLE CENTER DIRECTOR

Gary L. Messing, professor of ceramic science and engineering, has been appointed as Director of Penn State's Center for Particle Science and Engineering, succeeding Dr. Robert Santoro, professor of mechanical engineering.

The Center for Particle Science and Engineering was established in 1987 as an Intercollege Research Program to bring together the many Penn State scientists working in particle technology and encourage an organized focus on the research needs of the diverse industries whose products involve particulate systems. The range of industrial interests is enormous; including pesticides, peletized and crystalline industrial chemicals, granular fertilizers, detergents, food products such as sugar and flour, powder metals, ceramics, photographic emulsions, organic pigments, and at the finer scales, metal catalysts and fumed silicas.

The Center currently has 20 faculty members from the Colleges of Agriculture, Engineering, Science, and Earth and Mineral Sciences, with specialized expertise in particle research. Six major areas of focused research are established each with its own core faculty and associated laboratories: powder mechanics; processing and handling of particulate systems; nanoparticle synthesis, consolidation and superplastic deformation; physics and chemistry of particle surfaces; designed synthesis of particles; and the development and use of advanced particle characterization techniques.

It is Messing's goal as director to attract funding for research projects that will provide answers to problems involving the formation, processing and control of particles formed from gases, liquids and solids, and carry out new research on particle coatings and the chemical and physical modification of particle surfaces.

Messing, a member of the faculty since 1980 and elected Fellow of ACerS, is widely known for his work in powder science and sintering. In 1990 he served as chairman of the Basic Science Division of the American Ceramic Society and since 1988 has been an associate editor for the ACerS Journal.

FACULTY ACTIVITIES

R.V.Ramani, professor of mining engineering and head of the Department of Mineral Engineering, has been invited by the U.S. Secretary of Health and Human Services to serve on the Mine Health Research Advisory Committee of the Centers for Disease Control.

Ramani also served recently as an expert to the United Nations on computerized coal mining systems. As part of this assignment he visited government institutions and mining operations in Czechoslovakia, Yugoslavia, Poland and Turkey to review progress in the area of automated monitoring and control of mining operations, advise on future research and development projects, and discuss the impact of privatization and a market economy on coal mining industries.

Gregory S. Forbes, associate professor of meteorology, has been appointed as a member of the multi-agency Joint Working Group for Weather Support to NASA. He is the only university representative on the group, comprised of representatives of NASA, NWS, NOAA, and the U.S. Air Force. The panel will evaluate the weather support facilities and forecasting procedures used in daily operations at Cape Kennedy and other NASA launch and landing sites, in addition to appraising the weather-related criteria that affect launches and landings, and the ongoing and planned research in support of weather forecasting. Formation of this oversight group was recommended by the 1988 National Research Council Panel on Meteorological Support for Space Operations, chaired by Dr. Charles L. Hosler. Forbes was also a member of this NRC Panel.

Dennis W. Thomson, professor of meteorology and member of the graduate faculty in acoustics, has just completed a two-year IPA assignment to the Office of

Naval Research (ONR) in the Ocean Sciences Directorate, Division of Ocean and Atmospheric Physics. During this period he assisted scientists at ONR with the development of new long-term research programs in marine and boundary layer meteorology and ocean remote sensing. Particular areas of interest and opportunity included applications of the mathematical methods of nonlinear dynamical systems, inhomogeneous and nonstationary turbulence in the atmosphere and ocean, and use of high resolution Doppler radar and acoustical systems for atmospheric and oceanic measurements.

Z.T. Bieniawski, professor of mineral engineering, delivered a series of invited lectures in Poland, speaking on "Design Methodology for Design Engineers for Tomorrow" to the Polish Academy of Sciences Research Institutes in Gdansk and Cracow. He also inspected a construction site where his system of rock classification is being applied in engineering practice. Bieniawski has been asked to serve as an advisor to the Polish Ministry of National Education on aspects of curriculum revision for their technical universities.

At the XX General Assembly of the International Union of Geodesy and Geophysics, held in Vienna, **Peter J. Webster**, professor of meteorology, presented a paper on "Monsoon-ENSO Interactions: The Role of the Annual Cycle in the Coupled Ocean-Atmosphere System," and **Judith A. Curry**, associate professor of meteorology, gave a paper on the "Annual Cycle of Radiation over the Arctic Ocean: Sensitivity to Cloud Optical Properties."

H. Reginald Hardy, Jr., professor of mining engineering and director of the Pennsylvania Mining and Mineral Resources Research Institute, is serving on the organizing committee of the Seventh International Symposium on Salt, to be held in Kyoto, Japan, in April 1992 and has been invited to serve as co-editor of the conference proceedings. He will manage the technical sessions devoted to rock mechanics, structural geology, geochemistry, and dry mining and occupational safety. The Salt Symposia were originated in 1962 and are normally held every four to five years. Hardy also served on the organizing committee for the 4th World Meeting on Acoustic Emission, held in Boston in September.

John A. Ciciarelli, assistant professor of environmental science at the Penn State Beaver Campus is author of *A Practical Guide to Aerial Photography with an Introduction to Surveying*, published by Van Nostrand Reinhold. This general purpose textbook is designed for practioners in the field and includes sections on aerial photography, surveying, surveying mathematics and computer programs. Ciciarelli has previously written two textbooks in geology and is author of numerous professional articles. In 1987-88, he held a Fulbright Award to teach environmental geology and carry out research at the University of the West Indies, Barbados, and is currently working on several manuscripts resulting from this research. Ciciarelli is an EMS alumnus, receiving his M.S. in 1967 and Ph.D. in 1971, both in geology.

Richard L. Gordon, professor and Micasu Fellow of mineral economics, took part in a seminar on Energy Resources for the Future held at Hillsdale College, Michigan. He gave a paper on "Cutting Coal Regulation—Vanquishing the New Tartuffes," and made informal presentations on conservation and the necessity for human action to make "natural" resources economically usable.

Gary L. Messing, professor of ceramic science, gave a keynote address at the 5th International Meeting on Science and Technology of Sintering, held in Vancouver. He spoke on "Low Temperature Sintering of Seeded Alpha Alumina.

PNGE WELCOMES NEW FACULTY MEMBER

Phillip M. Halleck has joined the faculty as associate professor of petroleum and natural gas engineering. He comes to Penn State from the Terra Tek Drilling Research Laboratory in Salt Lake City, Utah, where he was senior project manager, responsible for the technical development of the oil well completions research program and principal investigator for a number of cooperative industry/agency investigations. He is coauthor of numerous articles and reports, most recently on aspects of perforation flow and stress effects in rock.

Dr. Halleck is no stranger to the College. From 1983 to 1985 he served on the faculty of the Department of Geosciences, during which time he carried out research on high-pressure elasticity in glasses and nonstochiometric oxides and studied relationships between in situ stress and microcrack orientation and closure pressure in recovered drill cores.

He was previously, from 1972 to 1983, a research staff member at the Los Alamos National Laboratory, working with the Geological Research Group and serving for two years as principal investigator of the Fossil Fuels Program. He received a B.A. degree in chemistry from the University of Rochester and Ph.D. from the University of Chicago, Department of Geophysical Sciences.

FACULTY PROMOTIONS

The following promotions in academic rank were announced by the University on July 1:

To Professor: **Bruce A. Albrecht** meteorology; **Christopher J. Bise**, mining engineering; **Kevin P. Furlong**, geosciences; **Thomas W. Gardner**, geology **August H. Simonsen**, environmental sciences McKeesport Campus; **Thomas T Warner**, meteorology.

To Associate Professor: **Jamal H Abou-Kassem**, petroleum and natural gas engineering; **Susan L. Brantley**, geosciences; **Derek Elsworth**, mining engineering; **Lee R. Kump**, geosciences; **Brian B. Tormey**, environmental sciences Altoona Campus.

25-year service awards went to: **John A. Dutton**, professor of meteorology and dean of the College; **John J. Cahir**, professor of meteorology and associate dean for resident instruction; **Shelton S Alexander**, professor of geophysics; **Peter Deines**, professor of geochemistry; and **David P. Gold**, professor of geology.

GEOMECHANICS HOSTS AE/MA CONFERENCE

The Fifth Conference on Acoustic Emission/Microseismic Activity in Geologic Structures and Materials was held at Penn State during the summer. The meeting, chaired and organized by **H. Reginald Hardy, Jr.**, professor of mining engineering, was well-attended and notable for its working discussions. In the three days of meetings, sessions were held on Mining Studies, Instruments and

Calibration, Analysis Techniques, Kaiser Effect Studies, Precursory/Process Zone Changes, Source Location/Network Design, Hydraulic Fracturing and Slopes and Construction. Participants ranged from geophysicists and fluid scientists to geological engineers and civil engineers from 14 different countries, including 14 scientists from Japan and 7 from Poland.

The conference was sponsored by Mineral Engineering's Rock Mechanics Laboratory and the Pennsylvania Mining and Mineral Resources Research Institute. The proceedings will be published by Trans Tech Publications, Clausthal-Zellerfeld, Germany.

8TH READ CONFERENCE ON ELECTRODEPOSITION

The Read Conference on Electrodeposition is held every three years at Penn State. It has a distinguished history, having developed from the original Gordon Research Conference on Electrodeposition when participants requested a three-year cycle over an annual meeting schedule. The conference is named to honor **Professor Harold J. Read**, professor emeritus of metallurgy and a well-known researcher and author on electroplating and hydrogen embrittlement, who was instrumental in bringing the meetings to Penn State in 1965.

The Read Conference is conducted in the style of the Gordon Conferences, in that all conference material is off-the-record and there are no published proceedings. Such a format has been found to be conducive to fuller and more informal discussions among leading researchers and development engineers.

In the three days of meetings in July, a wide range of topics were discussed dealing with the surfaces of materials, including sessions on additives, nanostructures, multilayered alloys, and the properties and processing of novel coatings. The conference was chaired and organized by **Howard W. Pickering**, distinguished professor of metallurgy; Professor Harold J. Read was honorary conference chairman.

GEOGRAPHERS HOST AAG REGIONAL CONFERENCE

Early in October, the Department of Geography hosted the 1991 annual conference of the AAG Middle States Division in meetings celebrating 200 Years of the United States Census.

Theme Sessions on "Historical Geography and the Census" and "The 1990 Census and the American City," and President's Sessions on political geography topics selected by Hunter College professor Keith C. Clarke, Middle States President, were interspersed by numerous student paper sessions. Workshops were held on "Census Data Adventures for Social Studies" and "The Census and TIGER" by members of the U.S. Census Bureau, on "Teaching Remote Sensing" by members of Hunter College and "Cartography on the Macintosh" by **David DiBiase** of the Deasy GeoGraphics Laboratory.

Highlights of the conference included field trips on local historical geography, led by Penn State's **Deryck Holdsworth**, and on ridge and valley landscapes by Ben Marsh '76 '83, now assistant professor of geography at Bucknell University. The banquet speaker was Arthur A. Davis, Secretary of the Department of Environmental Resources of the Commonwealth of Pennsylvania, who spoke on "The Environment: Challenges and Realities."

The conference was organized by **Peirce F. Lewis**, who presented an introductory address on local geography, and **Tina Jacquette**, research assistant.

DEASY LAB MAPS THE CAMPUS

The Geography Department's Deasy Geographics Laboratory recently expanded its work to address the issue of campus mapping. Maps of the University Park Campus were previously hand-drafted and produced by the University's Office of Physical Plant. With the constant changes to the physical layout on campus and the ever increasing variety of maps required, this has been an onerous task. Now, however, the Deasy Lab has come to the rescue by computerizing the entire operation.

The first of the new map series, a brightly colored map *Access Penn State* was produced in summer. It is designed to help people with disabilities find their way around the campus, classifying the accessibility of buildings and identifying problem areas such as steps and steep paths that might cause difficulties for those in wheelchairs. Other maps in preparation include parking maps and an exciting new three-dimensional representation of campus that will replace the current general purpose campus map. Projects such as these provide valuable training for the Geography students who work part-time at the Deasy Lab while studying for bachelors and advanced degrees.

A SMALL LOCAL EARTHQUAKE

On August 15, numerous residents of Centre Hall, Pa, the small community to the northeast of State College, were awakened by what many thought was a boiler explosion. After checking their homes, they returned to bed mystified as to why a quarry might be blasting in the middle of the night.

The event was clarified next morning when investigation showed that the community had been rocked by a small earthquake, measuring 3 on the Richter scale.

Since this was the first earthquake to be recorded in Centre County since 1941, it roused considerable local interest. The small tremor was of course recorded by the seismograph in the basement of Deike Building and also in New York, Virginia, and South Carolina. In order to pinpoint such a proximate source, the University seismograph had to be calibrated very precisely; this was done with the cooperation of a local limestone quarry. After initial investigation by **Charles Langston**, professor of geophysics and director of Penn State's seismic observatory, graduate student **Robert H. Clouser** took on the task of locating the source more accurately. His calculations placed the quake about eight miles northeast of State College, two miles southeast of Centre Hall. He estimates the depth to have been only about a quarter mile below ground, which accounted for the sound that awoke local residents. Clouser identified a buried fault on the geological map at that location and is tempted to attribute stress at this point to the cause of the earthquake. His best estimate is that the quake was probably oblique normal, with much less than a meter in vertical slip.

Plate Boundary Geometries of the San Francisco Region

Research on the tectonics of the San Francisco Bay area by **Kevin P. Furlong**, professor of geosciences, led recently to a major experiment to map the geometry of the fault system underlying this important earthquake zone.

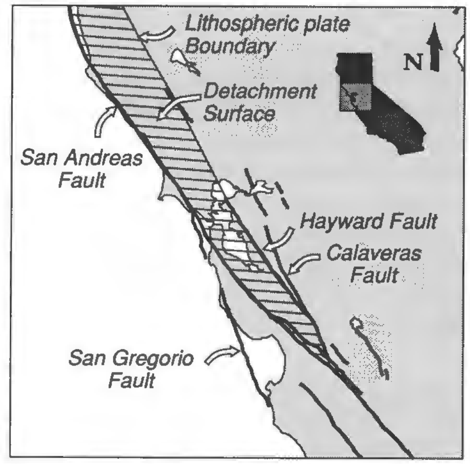
In September, a team of USGS scientists, supported by geophysicists from Stanford and the University of California, Berkeley, conducted two weeks of tests in which 15,000 compressed-air charges were detonated in the waters of the San Francisco Bay from the USGS research vessel *S.P. Lee*. Shock waves from the airgun blasts traveled down into the Earth's crust and reflected back seismic signals to an array of 100 underwater receivers and 250 seismometers placed at strategic locations in the Bay area. The aim was to define the subsurface geometry of the San Andreas and Hayward fault systems more precisely and to test whether, as Furlong contends, the two major fault systems are connected deep below the surface.

For the past several years, Furlong has been pointing out the critical importance of including the structure of the lower crust and upper mantle when evaluating the seismic history of the middle and upper crust in this region. He has used finite element and other numerical methods to model the three-dimensional structure of the boundaries of the crustal plates which meet beneath northern California and related these findings to the earthquake cycle that characterizes the area's seismic activity.

The area under study is just to the south of the Mendocino Triple Junction where the Gorda, North American and Pacific plates meet. The San Francisco Bay area involves the boundary between the North American plate and the Pacific plate. Earthquakes and movement along the faults associated with these crustal boundaries releases stress and strain caused as the plates press against each other. At the surface, the north-south trending San Andreas and Hayward faults are 20-30 miles apart in the Bay Area, but it has been noted that a number of major earthquakes in this century have been paired, with a quake on one fault followed within a period of a few years by an earthquake along the other.

Furlong's theoretical research, together with work by graduate students **William Hugo** '86 M.S. and current doctoral candidate **Dave Verdonck** '89 M.S. has led to the hypothesis that the deeper part of the plate boundary lies below the eastern [Hayward] fault system. And further, that the San Andreas fault, instead of plunging vertically downward into the Earth's crust, bends at a discontinuity surface in the lower crust, located perhaps eight miles below the surface, and thus joins the Hayward and other faults of the eastern system. Such a linkage would explain the apparent coupling of seismic events and offer new avenues of inquiry for evaluating earthquake hazard in this region.

Furlong will work with the USGS scientists to interpret the experimental observations and subsequently use the data to refine his model. Additional detailed modeling will then be carried out to learn more about the physical properties of the plate boundary in the San Francisco region.



A floating seismic transmitter (left) and (right), a seismometer site in the Bay Area.

Kevin Furlong and USGS geophysicist Jill McCarthy conduct a press conference on board the S.P. Lee.

THESES AVAILABLE

Following is a list of the advanced degree recipients and the titles of their theses or papers. Requests to borrow these may be made through the borrower's community, company, or University library. Libraries should address requests to: Interlibrary Loan Service, Pattee Library, The Pennsylvania State University, University Park, Pennsylvania, 16802.

A total of 70 degrees were granted by the College of Earth and Mineral Sciences at the University's 1990 Summer Commencement in August 1990. 32 bachelor of science degrees, 38 advanced degrees were awarded.

Ceramic Science and Engineering - Basil Richard Marple, Ph.D., *The Strength and Indentation Fracture Toughness of Mullite/Alumina Particulate Composites Fabricated by Infiltration Processing*; William Thomas Minehan, Ph.D., *Silica and Titania-Silica Powder Synthesis by Spontaneous Emulsification of Partially Hydrolyzed Metal Alkoxides in Water and Ethanol*; Toru Ono, M.S., *Synthesis of Ultrafine Ceramic Powders by the Reactive-Electrode Submerged-ARC Method*; Mianxue Wu, Ph.D., *Oriented Silicon Carbide Whisker Reinforced Mullite Composites: Laminate Processing, Structure, and Properties.*

Fuel Science - Guangwei Huang, Ph.D., *Ignition and Combustion of Single Millimeter-Sized Coal Particles*; Bongjin Jung, Ph.D., *Viscous Sintering of Coal Ashes in Combustion Systems.*

Geochemistry and Mineralogy - Francis Ors Dudas, Ph.D., *Petrogenesis and Mantle Source of Igneous Rocks in the Crazy Mountains, Montana*; Rigel L. Lustwerk, Ph.D., *Geology and Geochemistry of the Redstone Stratiform Copper Deposit—Northwest Territories, Canada*; Simon Roger Poulson, Ph.D., *The Geochemical Behavior of Sulfur in Silicate Magmas during Intrusion, with Respect to Magma-Country Rock Interaction*; Laurentius Bernardus Martinus Verburg, Ph.D., *The Ilmenite-Spinel Equilibrium in the System Iron-Titanium-Vanadium-Oxygen and Its Bearing on the Distribution of Iron, Titanium, and Vanadium in Igneous Rocks.*

Geography - Bruce Charles Hewitson, M.S., *General Circulation Models: A Validation of Synoptic Circulation*; Tamara A. Akins Mistrick, M.S., *The Effects of Brightness Contrast on Figure-Ground Discrimination for Black and White Maps.*

Geosciences - Lisa Cirbus Sloan, Ph.D., *Determination of Critical Factors in the Simulation of Eocene Global Climate, with Special Reference to North America.*

Metals Science and Engineering - Dong Hyung Kim, Ph.D., *Studies Concerned with Transport Properties of Pure and Oxide-Containing Molten Sodium Sulfate*; Makoto Nakamura, M.S., *Atom-Probe Study of the Oxidation of Cu-Ni Alloy.*

Meteorology - Jianwen Bao, M.S., *Accuracy of Cloud Forecasts Obtained from a Mesoscale Numerical Weather Prediction Model*; Stephen Layton Brueske, M.S., *Forecasting Atmospheric Particulate Sulfur Concentrations, Using National Weather Service Synoptic Charts*; Edward L. Chiang, M.S., *A Numerical Study of Three North Atlantic Polar Lows*; Timothy Scott Dye, M.S., *Structure and Circulation of Mesoscale Rainbands Deduced from a VHF and UHF Doppler Wind Profiler*; Jaser Khelaif Elsalem Rabadi, Ph.D., *Surface Layer Transfer Processes over Vegetation: A Micrometeorological Field Experiment of Long Duration*; Mark Klein, M.S., *Some Climatological Aspects of 12-Hour 500 MB Height Change over the North American Continent and Pacific Ocean*; Kevin Arlyn Kloesel, Ph.D., *Observational Study of the Above-Inversion Structure and Marine Stratocumulus Cloud Clearing Episodes during Fire*; Ming-Tzer Lee, M.S., *Analysis of Mesoscale Substructure of Cyclones and Jet Streams, Using Time-Space Conversion of VHF Doppler Wind Profiler and Rawinsonde Data*; Scott Anthony Mandia, M.S., *A Detailed Analysis of the EMEX 3 Tropical Convective Line, Determined by Aircraft Observation*; Rosemary Auld Miller, M.S., *Radiative Forcing on Numerically Simulated Tropical Cloud Clusters*; Julie Lee Schramm, M.S., *The Modification of Background Density Profiles in Thermohaline Convection*; Peter John Sousounis, Ph.D., *The Mesoscale Responses of a Locally Heated Planetary Boundary Layer*; Richard Joseph Walikis, M.S., *Using the Penn State UHF Wind Profiler to Obtain Raindrop Distributions during Mist*; Song Yang, Ph.D., *Atmospheric Teleconnections: Emphasis on the El Niño/ Southern Oscillation and Monsoons.*

Mineral Processing - Meftuni Yekeler, M.S., *Techniques for the Kinetic Analysis of Fine Grinding.*

Mining Engineering - Jian Liang Li, M.S., *Size, Shape, and Chemical Characteristics of Mining-Generated and Laboratory-Generated Coal Dusts*; Andrew Robert Piggott, Ph.D., *Analytical and Experimental Studies of Rock Fracture Hydraulics*; Mohammad Hossein Sadaghiani, Ph.D., *Analytical and Empirical Studies Related to Geotechnical Design of Mine Shafts.*

Petroleum and Natural Gas Engineering - John Paul Springer, M.S., *Core Characterization Using Computerized Tomography.*

Solid State Science - Nam Chul Kim, M.S., *The Role of Lanthanum Modification on the Fabrication and Properties of Lead Magnesium Niobate-Lead titanate Ceramics*; Andrew Wells Phelps, Ph.D., *The Vibrational Spectra of Diamond Polytypes and Defects in Diamond and Cubic Boron Nitride*; Wei Zhu, Ph.D., *Microwave Plasma Enhanced Chemical Vapor Deposition and Structural Characterization of Diamond Films.*

A total of 92 degrees were granted by the College of Earth and Mineral Sciences at the University's 1990 Fall Commencement in January 1991. 58 bachelor of science degrees, 34 advanced degrees were awarded.

Ceramic Science and Engineering - Rasto Brezny, Ph.D., *Mechanical Behavior of Open Cell Ceramics*; Ruth Ann Dudenhoefer, M.S., *The Mechanisms and Kinetics for Formation of Dimagnesium Phosphate Trihydrate*; Daniel Paul Heck, Ph.D., *The Effects of Point Defects and Carbon on the Precipitation of Oxygen in Silicon*; Donald Paul Heitzenrater, M.S., *Mechanical Properties and Failure Characteristics of Nickel/Alumina Composites Produced by Tape Casting and Lamination*; Debra Susan Horn, Ph.D., *Grain Growth Anisotropy in Titania-Doped Submicrometer Alumina*; Savitha C. Nanjangud, M.S., *Mechanical Behavior of Partially Sintered Ceramics*; Jay Scott Schickling, M.S., *The Tribological Properties of Silicon Carbide-Alumina Composites*; Eric John Van Voorhees, M.S., *Mechanical Behavior of Cellular Core Ceramic Sandwich Composites.*

Fuel Science - Anthony Alfred Lizzio, Ph.D., *The Concept of Reactive Surface Area Applied to Uncatalyzed and Catalyzed Carbon (Char) Gasification in Carbon Dioxide and Oxygen*; Prakash Ramachandran, Ph.D., *Sonically Enhanced Combustion of Coal Water Slurry Fuel.*

Geochemistry and Mineralogy - Gregg Jon Bluth, Ph.D., *Effects of Paleogeology, Chemical Weathering, and Climate on the Global Geochemical Cycle of Carbon Dioxide.*

Geography - Juan Manuel Gonzalez, M.S., *Sustainable Development and the New Politics of Nature: A Redefinition of International Development and the Implications for Third World Countries*; Roberto Mario Martin, M.S., *Integration in the Brazilian Amazon: Bringing Wishful Thinking in Line with Geographic Reality.*

Geophysics - Hye Sun Kim, Ph.D., *Higher Order Behavior of Earth Materials: Elasticity of Salt and Iron Oxide and Thermal Expansion at High Pressure.*

Geosciences - John Bernard Ritter, Ph.D., *Surface Hydrology of Drainage Basins Disturbed by Surface Mining and Reclamation, Central Pennsylvania.*

Metals Science and Engineering - Mark Alan Shehan, M.S., *High Temperature Corrosion Resistant Metal-Based Materials for Gas-Fired Systems.*

Meteorology - Loyal Leon Brooks, M.S., *Atmospheric Removal Efficiencies of Sulfur Compounds by Mid-Latitude Cyclonic Storms*; Clifton Elwood Dungey, Ph.D., *Backscattering by Nonspherical Particles, Using the Coupled-Dipole Method: An Application in Radar Meteorology*; Catherine Mary Heffernan, M.S., *The Effect of Cirrus Clouds on Radiative Heating Rates in the Tropical Monsoon Environment*; David Terrence Miller, M.S., *Mesoscale Convective Complexes in the Western Pacific Region*; Jeffrey Scott Tilley, Ph.D., *On the Application of Edge Wave Theory to Terrain-Bounded Cold Surges: A Numerical Study.*

Mineral Processing - Charles E. Zebula, M.S., *Selective Flocculation, Dispersion, and Froth Flotation of Western U.S. Oil Shale.*

Mining Engineering - Dwayne Curtis Kicker, Ph.D., *The Theory and Methodology of Rock Mechanics Design*; Aso Masutomi, M.S., *The Application of Loss-Control Principles for the Reduction of Human-Performance-Based Accidents and Injuries at the Continuous-Miner Worksite.*

Polymer Science - Dorab Edul Bhagwagar, M.S., *Mapping the Phase Diagram of an Aromatic Polyamide Blend, Using Infrared Spectroscopy*; Lloyd Edwin McDaniels, M.S., *A Study of Adhesion and Mechanical Properties of Polymer-Metal Laminates*; Prabodh Pannalal Sharma, M.S., *Hydrodegradable Copolyesters: Synthesis via Simple Ester Exchange Reactions, Characterization, and Degradation Studies.*

Solid State Science - Ruyan Guo, Ph.D., *Ferroelectric Properties of Lead Barium Niobate Compositions near the Morphotropic Phase Boundary*; Hien Van Nguyen, M.S., *Magnetic Levitation Using High Temperature Superconductor-Polymer Composites*; William J. Paulus, M.S., *Synthesis, Characterization, and Cation Exchange Selectivity of a Highly Charged Sodium Fluorophlogopite Mica*; Deborah J. Smith, M.S., *Ultraviolet Curable System for Ceramic Tape Casting*; Cheryl Marie Vaughan, Ph.D., *Crystal Chemistry and Ceramic Processing of Rare Earth Chalcogenide Optical and Electronic Materials*; Nancy Jean Wlodarczyk, M.S., *Nanocomposite Versus Monophasic Processing of Gels and Glasses in the Lithium Aluminosilicate System*; Joyce Kuniko Yamamoto, Ph.D., *Growth and Characterization of Ferroelectric Single Crystal Fibers Produced by the Laser-Heated Pedestal Growth Technique.*

M.J. Gallagher "Culm Bank" (Steidle Collection, College of Earth and Mineral Sciences)

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