DEPARTMENT OF GEOLOGICAL SCIENCES
The University of Michigan
1006 C. C. Little Building
Ann Arbor, MI 48109-1063

First Class

Address Correction Requested

GEOSCIENCE NEWS

for alumni and friends of the
Department of Geological Sciences
The University of Michigan, Ann Arbor, Michigan

June 1995

New Chair

Rob Van der Voo hands over the job of running the department to the new Chair, Dave Rea. Hard hats and sledge hammers are essential administrative equipment while the renovation of C. C. Little continues.

In this Issue:

Greetings from the Chair

GREETINGS!

The greetings this Spring mark a particular occasion for me, because on July 1 there is to be a new Chair: it is Prof. David K. Rea who has been appointed by our Dean to lead the Department into the next century (until July 1, 2000, to be precise). Dave has been a faculty member at the University since 1975 and has taught oceanography, marine geology and geophysics, tectonics, paleoclimate studies, as well as the geology of the Great Lakes. He transferred to our Department in 1987 from Atmospheric, Oceanic and Space Sciences in the Engineering College. Dave has also served as Program Director at the National Science Foundation and as Interim Director of the Center for Great Lakes and Aquatic Sciences at the University. In her announcement to the departmental faculty of the appointment, Dean Edie Goldenberg concluded: "he will need your support in this endeavor, and he has mine." The same is true for you, members of our alumni body: the new Chair will need your support!

Writing my last column in this place gives me the opportunity to reflect on the rapidly changing environment in which geoscience departments nationwide are functioning. The changes in the international area have been truly fundamental, with ripple effects that are advantageous as well as detrimental to geoscience research. New and relatively abundant opportunities for scientific collaboration with colleagues in eastern Europe and the former Soviet Union have presented themselves in ways that no one could have predicted. Offsetting these positive effects are reduced funding opportunities for specific scientific research that used to be driven by a competitive environment during the cold-war era, and exacerbating these pressures to reduce research budgets are the national deficit, a strong desire to diminish taxation, and concerns about the growing costs of social security and medicare. At the same time, public confidence in the effectiveness of higher education has not remained as high as it used to be, and the notion that scientific research is a necessary ingredient in the activities of a modern society appears to be fading. Concerns for the environment remain high, but remediation is favored at the expense of the polluter, with the government playing a less active role. All these pressures, collectively, act like a diamond-anvil cell on funding for traditional earth-science research; this funding, behaving according to the ideal gas law, seems to shrink linearly with pressure while at best generating some heat.

Earth-science instruction increases in relative importance when research budgets shrink and the Department should be (and is) actively planning the transition to a new paradigm of university job descriptions. A little bit of such planning is mentioned below; undoubtedly you will read more about this in future issues of Geoscience News.

This Summer will be the zenith (some will say nadir) in the activities related to the renovation of the C. C. Little Building. Almost everything will be done at once, all floors will be impacted, the nearest functioning bathroom will be in the Museum, the elevators will be demolished, no air will be conditioned, and all that so that after August 20 the roofs won't leak, the pipes won't burst, the radiators won't clang, the windows will be transparent and draft-free, the faculty will be happy and won't worry (about funding), the staff will get huge raises, the deans can finally go on vacation, and the students will earn all A's.

The courses in which these students will earn their A's will soon include quite a few new offerings. They will form part of a new undergraduate degree program in Environmental Geology. The program has been approved by our College and will, pending approval by the State of Michigan's Presidents' Council, start in 1996. Characteristic of the program is a strong emphasis on cognate science fields, whereas in the Department, courses such as hydrogeology, surficial processes and materials, and aqueous geochemistry will feature prominently.

So, as you see, we keep on being busy. Never a dull moment! But when you are back in Ann Arbor, please stop by, we will always have time for you. You can then admire our building, say hello to the new Chair and to old friends!

Sincerely,

Rob Van Der Voo
Chairman

Database Audit

The Department is undertaking a major revision of its Alumni Database, which among other things provides the mailing list for the Geoscience News. We try to update the addresses on a regular basis, but over the past few years some of the other information has become incomplete or outdated, to the point where we feel a major effort is warranted. Therefore, we request that ***everyone*** receiving the Geoscience News please complete and return the information form on page 17. Many thanks!

Geoscience News is compiled twice a year for alumni and friends by the Department of Geological Sciences at the University of Michigan, Ann Arbor MI 48109-1063

Editor: A. N. Halliday

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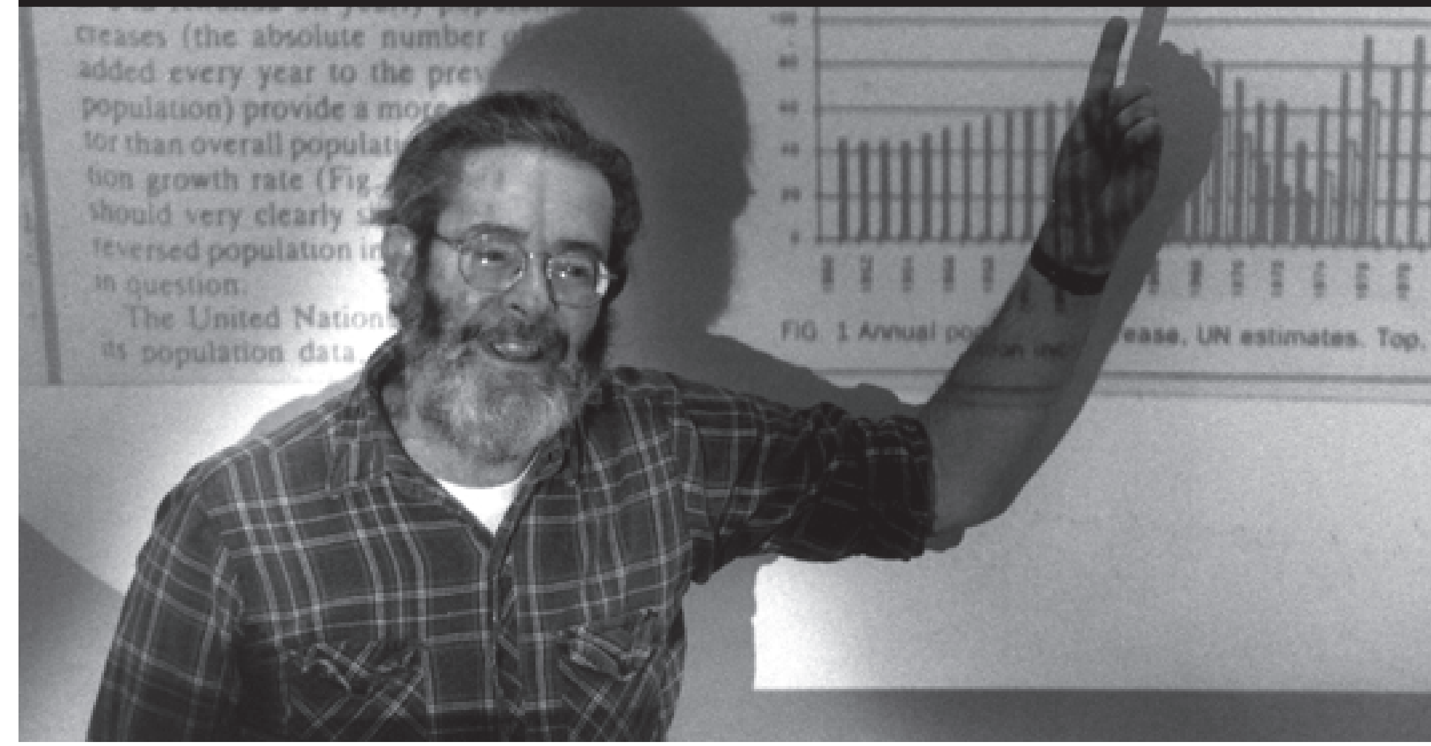
It's An Ill Wind...Blowing Some Good



by Sally Pobojewski

Nobody has anything good to say about smog. It burns our eyes, hurts our lungs, kills plants, acidifies lakes and spoils the view. Environmental activists and government officials have spent millions of dollars and written reams of legislation in an attempt to get rid of the stuff.

According to Jim Walker, Arthur F. Thurnau Professor of Atmospheric, Oceanic and Space Sciences and of Geological Sciences (pictured above), the blanket of air pollution that hangs over much of the industrialized world has a benevolent side. He says it could be protecting us from the full impact of other serious environmental threats, such as global warming and depletion of the ozone layer.

A Boon of Bad Air

"Bad air does have its benefits," says Walker. "But by masking the effects of other environmental problems, it may be lulling us into an unmerited complacency. Environmental damage may already be worse than we think."

A specialist in global change issues, Walker's laboratory is the Earth itself. He's interested in how human activities—particularly the widespread burning of fossil fuels like oil, natural gas and coal—are changing the global ecosystem in fundamental ways that scientists do not fully understand.

One of the more publicized and controversial changes is global warming. When we humans burn fossil fuels to run cars or power plants and factories, tons of carbon dioxide and other greenhouse gases rise into the atmosphere and remain there for hundreds of years. Although not as visible as the smoggy haze of air pollution, greenhouse gases are just as dangerous. Like the plastic cover on a greenhouse, they trap heat near the Earth's surface and prevent it from radiating into space. With no way to escape, the heat builds up and our planet gets warmer.

If the trend continues, scientists say average temperatures could climb by 3 to 8 degrees F in the next 50 to 100 years—a level of warming unmatched since the end of the last Ice Age 10,000 years ago.

Why the Erratic Pattern?

The pattern of global warming has puzzled scientists, however. Since the beginning of reliable meteorological records about 1850, the amount of carbon dioxide in the atmosphere has climbed at a steady rate, but records show the warming effect of CO_2 has been erratic rather than steady, with periods of nearly constant temperatures separated by periods of rapid increase.

Walker wondered why global temperatures have not increased in a more uniform pattern and began looking for possible explanations. When he compared meteorological data and economic statistics, he noticed that "average global temperatures have increased during periods of economic recession and remained unchanged during periods of rapid economic growth."

"It occurred to me," he says, "that competition between warming greenhouse gases like carbon dioxide and cooling air pollutants like aerosols, soot, ash and smog might explain the erratic pattern in global warming. Perhaps the pollutants spewing into the atmosphere from factory smokestacks and automobile tailpipes are deflecting some incoming solar radiation and keeping the Earth cooler than it otherwise would be."

Those Cloudy Days

Another factor that may be contributing to the cooling effect of air pollution is the increase in cloud cover. Summer cloud cover over the United States, for example, is 10 percent greater than it was in 1900.

Scientists don't know why cloudiness is increasing, Walker says. "It might be some natural variability of the climate system," he speculates. "It might be a response to global warming. It might very plausibly be a response to increasing concentrations of dust, smog and haze in the atmosphere caused by industrial and agricultural activities."

Clouds form when water droplets collect around tiny particles called cloud-condensation nuclei, Walker explains. "The concentration of cloud condensation nuclei in industrial areas has increased in the 20th century as a result of industrial activity," he says. "So it's probably no coincidence that cloud cover is increasing, also." The more tiny pollutant particles in the atmosphere, the more water droplets in each cloud. This increases the tendency of clouds to reflect sunlight back into space and cool the Earth.

Another important phenomenon related to competition between the warming effects of greenhouse gases and the cooling effects of industrial pollutants is how long they remain in the atmosphere. "Carbon dioxide remains in the atmosphere for hundreds or thousands of years," Walker points out, so if greenhouse gases were the only influence on global temperature, we would expect a smoothly climbing warming curve.

But sources of the competing, cooling effect—air pollutants like sulfuric acid, aerosols and ash from smokestacks and tailpipes—stay in the atmosphere for just a few days or weeks. And until they're washed out of the atmosphere in precipitation, the hazy smog or clouds they produce block sunlight and cool the Earth.

"During periods of rapid economic growth, when factories and power plants are expanding production, the quantity of pollutants in the air increases rapidly and produces a short-term cooling effect," Walker says. "When the economy slows down, the pollutant level drops off rapidly, leaving us exposed to the full impact of global warming again."

Walker emphasizes that his idea about the relationship between global warming and the global economy is just that—an idea, not a valid scientific study. He does find it intriguing, however, to compare rates of warming with historical economic trends.

Stability Till WWI

"From about 1850 until World War I, global average temperatures didn't change significantly," Walker says. "This was during the Industrial Revolution when fossil fuel burning increased at a nearly constant 5 percent annual rate."

From World War I (1914-18) until the end of World War II (1945), global temperatures increased rapidly. "This correlates with slower growth in the economy—especially with the factory closings during the Great Depression in the 1930s—and the corresponding drop in the amount of cooling pollutants spewed into the atmosphere."

From the mid-1940s to the mid-1970s, there was little or no change in global average temperatures. "These were the years when nobody paid any attention to global warming, because the globe seemed to be cooling off—or at least not warming up," Walker says. "This also was a time of post-war economic boom, with renewed rapid growth in fossil fuel consumption and a corresponding surge in air pollution."

Then came the oil crisis of the mid-1970s, escalating oil prices, the worldwide recession of the 1980s and a sharp drop in industrial productivity. "And what happened to global temperatures?" Walker asks. "They just went rocketing up. Nearly all the hottest years on record were in the 1980s."

If Walker is right about the relationship between global warming trends and the world's economy, what does he foresee in the world's future as it moves into a global economic recovery?

"If the analysis is correct and the economy continues to pick up, then average global temperatures will not increase as fast as they have since the late 1970s," Walker says.

Classic Case of Catch 22

According to Walker, it's a classic Catch-22 situation. When economic times are good, we do serious long-term environmental damage by dumping tons of additional carbon dioxide and other greenhouse gases into the atmosphere. Since weather conditions seem normal, however, people stop worrying about global warming and have no incentive to make the lifestyle and economic sacrifices needed to reduce fossil fuel emissions.

When economic times are bad, factories shut down, reducing pollutant haze, and temperatures go through the roof. Confronted with heat waves, drought and massive hurricanes, people worry about the environment again, but faced with the social and economic impact of widespread recession, have no resources left to invest in environmental problems.

"We are in a race between environmental destruction and human attitudes on how to deal with it," Walker says. "It's not clear which side will win."

Jim Walker has no idea how long the Earth can continue its delicate balancing act between greenhouse warming and pollutant cooling. He doesn't know how much time scientists have left to anticipate the effects global warming will have on life on Earth, or how much time policy-makers have to develop a plan to deal with it. But he does know one thing" The benefits of bad air are illusory and only temporary.

The above article originally appeared in the magazine Michigan Today and is reproduced with kind permission. Sally Pobojewski is a science writer with U-M News and Information Services.

Geolumni Information Form

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Name ______________________ Residence Telephone __________
Surname First Middle Area Number

Residence Address ______________________
Street Address City State Zip

Business Address ______________________ Business Telephone __________
Position Company Area Number

____
Street Address City State Zip

Degree __________ College or University ______________ Year ______

Degree __________ College or University ______________ Year ______

Degree __________ College or University ______________ Year ______

Spouse ______________________
Name Year of Wedding

Children ______________________
Name Birth Date Name Birth Date

Children ______________________
Name Birth Date Name Birth Date

Children ______________________
Name Birth Date Name Birth Date

Reference Address (name and address of parents, nearest relative, or someone who will be able to reach you):

Name ______________________ Telephone __________
Relationship Area Number

____
Street Address City State Zip

Please send us any news of your "doings" to be included in the next newsletters; simply write it on the reverse side of this sheet.

Degrees Granted

BS

Christopher Buehrer
Nathaniel Diedrich
Karen Fashoway
Laura Forman
Keri Garver
Brent Hoffman
Payal Parekh
Adam Tomasek
Ronald Tykoski
Marc Weber

MS

Eleanor Dixon "An evaluation of hornblende barometry, Isabella to Tehachapi region, southern Sierra Nevada, California"

Elizabeth Kowalski "Glacial-Interglacial Variations in Delivery of Organic Matter to Quaternary Sediments at DSDP Site 594, Chatham Rise, Southeastern New Zealand Margin"

Sean Paulsen "A Quantitative Model of Sediment Dispersal and Heavy Mineral Distribution in North Cardigan Bay, Wales"

Lisa Churchill "Relationships between Changes in Size and Extinction Intensity in Trilobita: Testing for Differences in Selection Regimes during Mass and Background Extinctions"

James S. Cureton "Late orogenic normal faulting along the Mooroton shear zone, Grenville Province, Ontario, Canada"

Andrew J. Mughannam "Stable isotope constraints on the origin of a zoned plutonic sequence, Tuolumne Intrusive Suite, central Sierra Nevada, California"

Ella Reinhard "$^{18}O/^{16}O$ Ratios of Cave Bear Tooth Enamel: A Record of Climate Variability during the Pleistocene"

Gabrielle Tenzer "Sources and Distribution of Carbonate and Organic Carbon in Sediments of Pyramid Lake, Nevada"

Sean M. Todaro "Near-Laurentian paleogeography and accretionary history of the Lawrence Head Volcanics of central Newfoundland, northern Appalachians"

Rodrigo Vazquez "Carbon and Oxygen Isotope Halos in the Host Limestone, El Mochito Zn Pb (Ag) Chimney-Manto Skarn Deposit, Honduras"

Liping Wang "Diffusion of Hydrogen in Pyropic Garnet"

Egon Weber "Rift Evolution and Deformation Partitioning Across a Zone of Crustal Weakness in the Central Basin of Lake Baikal"

Wen Yi "The Separation and Precise Determination of the Concentrations and Isotopic Compositions of Indium and Tin in Geological Materials"

Pinbo Zhou "Nd-, Sr, Pb-isotopic, and major- and trace-element geochemistry of Cenozoic basalts from the Khorat Plateau, Thailand: Sources and petrogenesis"

PhD

Brian Eugene Bodenbender "Skeletal Crystallography in Cladistic and Stratocladistic Investigations of Blastoid Phylogeny"

John Patrick Encarnacion "Geochronological, Geochemical and Geological Constraints on Models of Ophiolite Generation and Arc Growth: Evidence From the Northern Philippines"

Joseph Robert Graney "Applications of Mass Spectrometry in Economic Geology and Environmental Geochemistry: Gas Composition of Inclusion Fluid From Ore Deposits and Sources of Lead Pollution in Lake Sediments"

In Memoriam

Fred M. Bullard (BS '21, PhD '28) died July 1994.

James Lewis Calver (AB '36, MS '38, PhD '42) died December 1994.

John W. Johnson, Jr. (BS '45, MBA '47) passed away during the summer of 1994.

Robert A. Berner
Wins the 1995 V. M. Goldschmidt Award

Bob Berner (BS '57, MS '58) has been awarded the Goldschmidt Medal of the Geochemical Society in recognition of his outstanding contributions to sedimentary geochemistry. Bob and his wife Betty (BS ' 58) (then **Elizabeth M. Kay**) are alumni of our department. They published a textbook together, *Global Water Cycle: Geochemistry and Environment* with Prentice-Hall. While at U-M, Bob was greatly influenced by Professor **Lou Briggs**. Bob and Betty now teach at Yale and the University of Connecticut respectively. John Morse (Texas A&M) was the citationist at the recent Goldschmidt Conference at Penn State. Much of what follows is condensed from his citation with kind permission.

Bob Berner's outstanding accomplishments are reflected in the fact that he is among the most frequently cited members of the Earth sciences community in scientific literature, a past President of the Geochemical Society, and was made a member of the National Academy of Sciences at a relatively young age.

Bob was born in Erie, Pennsylvania, close to 60 years ago. He grew up, among other places, in Michigan where his many humorous stories about the Pickle Boat and the Pharaoh were spawned. (By the way, for those of you have wondered what "HTP" means in his papers, it is not high test pure, but hail the Pharaoh!). The University of Michigan provided Bob with his BS and MS degrees, and from there he went on to study for his PhD at Harvard with Ray Siever. During his time at Harvard, several important events occurred that shaped much of Bob's life. Among these were the start of his long-lasting personal and professional interactions with Bob Garrels, who became a major influence on his scientific career, and marrying fellow graduate student Elizabeth Kay. After finishing his PhD, Bob went to Scripps Institute of Oceanography as a Sverdrup Postdoctoral Fellow in 1962, followed by a brief time on the faculty of the University of Chicago, and finally, in 1965, he joined the faculty at Yale where he is now the Alan M. Bateman Professor of Geology.

During the early part of his career in the 1960's, Bob's attention was focused primarily on processes associated with the early diagenesis of sediments, with particular emphasis on the formation of authigenic pyrite. This research revealed the complexity of interrelationships among physical, chemical, and biological processes occurring near the sediment-water interface and inspired Bob to start to develop his now legendary mathematical models for diagenesis, which have resulted in two books. In 1971, his first book on sediment diagenesis was published and he received the Mineralogical Society of America Award given to outstanding young geoscientists. Perhaps few people appreciate that one of the most important impacts of this early work was to start the field of "low temperature" geochemistry moving away from a strong reliance on equilibrium thermodynamics which had proven so successful in its application to metamorphic and igneous petrology and geochemistry.

From the mid-1970s to 1980s, Bob continued his innovative work on sediment diagenesis that came to include studies of the formation and behavior of methane in sediments, development of the quantum-G model for sedimentary organic matter diagenesis, investigation of iron mineral diagenesis and phosphate diagenesis, and demonstration of the utility of sedimentary C/S ratios as indicators of paleo-depositional environments. At this time Bob also became involved in research on silicate weathering reactions where he introduced X-ray photoelectron spectroscopy (XPS) to the study of the surface chemistry of silicate minerals undergoing dissolution.

Although Bob has continued to carry out research on a wide variety of topics dominantly associated with the early diagenesis of sediments, his most remarkable work in recent years has been modeling the global carbon cycle and the role it plays in controlling atmospheric oxygen and carbon dioxide, and global climate over Phanerozoic time. A considerable portion of this research is included in the famous BLAG model that was constructed with Bob Garrels and Tony Lasaga. Currently, Bob continues to evolve his GEOCARB model and is particularly interested in how the evolution of land plants may have influenced global weathering rates and the carbon cycle.

Bob Berner stands out as a shining example of how "small" curiosity-driven science can produce big results; a fact that seems to be increasingly lost by federal funding agencies and bureaucrats. He has not been an empire builder, but preferred to work with modest funds, relatively simple equipment, and small groups of individuals whom he has generally become closely associated with on a personal basis. Doing truly innovative work that results in major advances in a field inevitably leads to controversies as preceding hypotheses and theories are challenged. Throughout it all, however, Bob has always remained a true gentleman whose goal was not "winning or losing" but rather trying to find the best scientific explanations that could be revealed by existing data and theories.

R. Lawrence Edwards
wins George W. Taylor Award

Larry Edwards (MS '86) is this year's recipient of the prestigious George W. Taylor/Institute of Technology Alumni Society Award in Research of the University of Minnesota. The award is made annually to a young faculty member who has shown outstanding ability in research. The Taylor awards are endowed within the institute in memory of George W. Taylor, a 1934 graduate of the Mechanical Engineering Department. Each year in an institute-wide competition this research award is conferred to one of the 407 faculty members in the Institute of Technology.

Larry Edwards obtained an MS degree at U-M in 1986 working on the petrology of the major paragneiss in the Northwest Adirondacks with **Eric Essene**. His thesis was published in 1988 in the Journal of Petrology. He obtained his PhD in 1988 from Cal Tech working with Gerry Wasserburg and pioneered the precise determination of the timing of sealevel changes over the past 200,000 years using U-Th dating of carbonates. Larry grew up in Ann Arbor and attended MIT as an undergrad. His father is a U-M faculty member (now emeritus) in Chinese Studies. His mother, Vi Edwards, from China, was a potter of repute. Larry was hired as a radiogenic isotope geochemist at the University of Minnesota in 1988.

Rebecca A. Lange
wins the F. W. Clarke Medal

Becky Lange (U-M faculty) is the 1995 recipient of the Clarke Medal of the Geochemical Society, awarded to a young geochemist for a single outstanding contribution to geochemistry. Much of what follows is extracted with kind permission from the citation of Ian Carmichael given at the recent Goldschmidt Conference at Penn State.

Becky did her undergraduate and graduate education in geology at U-C Berkeley. As an undergraduate she became intrigued by the phase transitions in $KAlSi_2O_6$, $KAlSiO_4$ and their iron analogs, and measured their heat capacities and enthalpies of transition on the differential scanning calorimeter; the results were written up while she was an undergraduate.

As a graduate student, she pursued two complementary approaches, one an experimental problem involving the thermodynamic properties of multicomponent silicate liquids, and the other a field study in Mexico. She measured the density and thermal expansion of silicate liquids over a wide compositional range, which allowed her to demonstrate with high precision how silicate liquids mix with respect to volume. By recasting her results as partial molar oxide volumes, she has provided petrologists with the means to calculate melt densities as a function of temperature and composition. Moreover, her data have greatly improved the reformulation of sound speed data into a model for the compressibilities of silicate liquids, so that her data can be used to represent the densities of anhydrous melts at elevated pressure.

Her data have several applications. First, the magma physicists assure us that density contrasts of less than 1% can lead to important convective phenomena in magma chambers. For the first time, we can model the density of natural liquids within this precision. Second, her data allow crystal-melt equilibrium calculations to be extended to high pressure through integration of VdP terms. This application is perhaps the most important and often the least appreciated; until recently, it has been notoriously difficult to achieve equilibrium with clinopyroxene and to quench small degree partial melts in high-pressure experiments. Her density data allow the MELTS thermodynamic model, developed by Mark Ghiorso, to predict the products of small-degree mantle melting at high pressure. The predicted compositions have been recently corroborated by experiment at Caltech using diamond aggregates. Finally, the volume data are an important probe of silicate melt structure.

The other part of her PhD thesis involved mapping an isolated and mountainous area in western Mexico where an extraordinary suite of potassic, hydrous and oxidized magmas coexists with the more common products of arc volcanism, namely basaltic andesites and andesites. Her geologic mapping showed that these small volume, hydrous lavas are confined to extensional grabens, so that their ascent to the earth's surface is entirely dependent on the fault pathways which may extend to the lower crust. She established that this suite of potassic magmas preserves evidence of surprisingly high magmatic water contents and oxygen fugacities, some approaching the H-M buffer. The extreme arc signature of these magmas indicates that they may be nearly direct fusion products of hydrous veins in subduction-modified mantle, and therefore may be the most direct evidence we have of the composition of slab-derived fluids.

After her luxurious life as a graduate student, with annual field excursions to Mexico, her experimental experience, and the obsession she developed for getting the experiment right, took her to Princeton to work as a postdoc with Alex Navrotsky. In two years they provided the first data on the latent heat of crystallisation of a cooling natural liquid and demonstrated that because the order of crystallisation affects the release of latent heat, each magma is unique, with consequences for magmatic cooling models.

Four years ago the University of Michigan became aware of this versatile young scientist who is as much at home in the field with rocks and their irrational nomenclature as with the vicissitudes of calorimetry or with an intricate thermodynamic argument. In an ideal match she became an assistant professor at Ann Arbor, where her students are also learning the horrible truth that most experiments seem to go wrong.

There are two essential ingredients that have helped Becky become a successful scientist; first, you should get data of impeccable

Peninsula about 10,000 years ago. The third main target of the cruise will be the recovery of the varved sequences of sediments deposited just prior to and after the Main Algonquin highstand of the Lakes (about 10,000 to 100,000 years ago). This interval should yield a high resolution record of regional climate variability just prior to and just after a major interval of climatic cooling.

David Polly (visiting Assistant Professor) has managed to finish teaching GS 439, as well as 125. In spite of spending most of his time writing lectures, he still managed to submit two papers, one on the phylogeny of the mammalian group Hyaenodontidae and the other on internet distribution systems with Robert Guralnick for an edited volume to be published by Cambridge University Press sometime in the undetermined future (probably after it is long outdated). David is continuing work on various projects, including the study of the enamel ultrastructure of Hyaenodontidae (with Alexander Lavrov of the Paleontological Institute in Moscow) and trying to test the relative roles of functional selection and developmental constraints in the evolution of mammalian molar morphology. If he can get funding from LS&A, David will be presenting a paper on neo-Lamarckian biological classification in Leuven this July and, once again if he can get funding, will be accompanying **Gregg Gunnell**, **John Bloch**, and **Will Clyde** on their Kazakhstan expedition.

The winter and spring of 1995 finds **Dave Rea**'s student **Hilde Snoeckx** in the final throes of thesis writing. Her work on sediment cores from the eastern Equatorial Pacific has enabled her to define the history of latitudinal variability of both oceanic and atmospheric circulation, especially the shifting of the intertropical convergence zone. **Dave Dobson** is beginning a thesis on the variability of tropical climates on all timescales, from the short periods of the El Nino - Southern Oscillation, to the tectonic timescales of Andean uplift. **Libby Prueher** passed her preliminary exams and is setting out on a thesis that will investigate potential links between explosive volcanism and climate change. **Leah Joseph**, who has the added task of dealing with an advisorial troika (Dave, **Ted Moore**, **Ben van der Pluijm**), is beginning an investigation of various physical records of all oceanic sedimentary processes. This past semester, in addition to the normal (but never routine) teaching, research and service tasks, Dave has been spending much of his time with the department's Internal Review Committee (**Van der Voo**, **Kesler**, **van der Pluijm**, and Rea). This group has been working hard since last fall compiling all the information we can find about our whole effort, concentrating on the last 5 or 10 years. The result will be a 9-chapter volume and appendices that will be presented to our Dean and to the committee of external reviewers that will visit us in October. News of this review will be the main topic of the newsletter published in late fall. Dave has been asked to serve as the next chair of this department and is looking forward to the new challenges this will bring. You will be hearing more from him in the chair's letter in upcoming issues.

Ben van der Pluijm enjoys the new location of his office and particularly its proximity to the new Structure Lab. Away from the dust and noise elsewhere in the Department, the new space is a peaceful haven frequented by many (including its recent designation as prime spot for informal get togethers). On the research front, the Appalachian project with **Rob Van der Voo** continues to occupy much of his time; a meeting dedicated to the retiring Hank Williams (the fiddling Appalachian geologist, not the country singer) prompted a controversial paper based on our ongoing studies (co-authored with Rob and visiting scientist **Trond Torsvik**). **Sean Todaro** (now at Woodward-Clyde) completed his MS thesis on Newfie rocks, whereas **Liz Meyers** has reached the final stages of her project on mainland Silurian rocks. A new post-doctoral fellow, **Conall MacNiocaill**, will join the project later this Spring (actually, Spring is a misnomer for the cool days we are having as I write this). Formally deeper in the crust, Grenville rocks are telling us that regional extension dominated the latter history of this Mid-Proterozoic orogen, in a structure-petrology-geochronology project with **Eric Essene**, **Chris Hall** and **Alex Halliday**. PhD students **Jay Busch**, recently graduated **Jim Cureton** (now in Tomei working for the Peace Corps) and NSF post-doc **Jerry Magloughlin** are doing the hard work, cheered on by this chorus of Michigan faculty. A return to US Midcontinent geology is headed by new graduate student **John Harris** (MS), and the link between oceanography and structural geology is kept alive by the magnetic anisotropy work of **Leah Joseph** (MS). The world of mica microstructures continues to release its secrets to the new high-resolution X-ray texture goniometer (HR-XTG), in the project with PhD student **Nei-Che Ho** and **Donald Peacor**. Studies on slates in Wales and in the Upper Peninsula (a structural geologist working in the mountains of Michigan!) are our current studies. Meanwhile, Ben continues to work on calibrating magnetic anisotropy as a gauge of fabric intensity and deformation kinematics as well as further developing low-temperature (77K) methods, with the help of research scientist **John Stamatakos** and Barcelona visitor **Josep Casanova Pares**, whereas two new undergraduate classes present the educational challenge for the upcoming academic year.

In the early Fall, the entire structure / tectonics cast went on its annual "deformed field" trip, where this picture was taken (in Vermont). Pictured, L to R: Liz Meyers, Nate Winslow, Don Cedarquist, Rob Van der Voo, Josep Pares, John Harris, Nei-Che Ho, Leah Joseph, Peter Tropper, John Stamatakos, Trond Torsvik, Ben, Jerry Magloughlin, Jay Busch measurements yet of the concentrations of the volatile elements indium and tin in the Earth and shown that the Earth is less depleted in indium than it is expected to be, possibly explained by more oxidizing conditions in the later stages of accretion. Also these techniques have allowed the preliminary development of In-Sn geochronology of sulfides. **John Christensen** (postdoctoral fellow) has been leading the way with Rb-Sr dating of sulfides but has now been sidetracked into developing *in situ* strontium isotopic measurements using laser ablation. The strontium, lead and tungsten isotope data generated so far by MC-ICPMS with laser ablation are the most precise accurate *in situ* isotopic measurements of any kind yet made. Some of these results were presented at the recent Goldschmidt Conference of the Geochemical Society at Penn State. Also, at the same meeting, **Carsten Israelson**, a visiting student from Copenhagen, presented new U-Pb data for carbonate concretions that permit accurate calibration of the Lower Paleozoic timescale and the determination of sediment compaction rates. This work nicely complements the work of graduate student **Hailiang Dong** whose new method of ^{40}Ar-^{39}Ar dating of diagenetic clays was published in *Science* earlier this year. A new postdoctoral fellow **Mark Rehkämper** has recently joined the group from Mainz. Mark's expertise is in mantle geochemistry, HPLC and chemical separation techniques and he is currently developing new methods of platinum group element analysis. Finally, two new graduate students **Dan Barfod** and **Xiaozhong Luo** are just starting their research projects in noble gas geochemistry and U-Th disequilibrium studies, respectively.

Record numbers attended this year's Dorr Dinner. Those present included Carl Drummond (2nd from left, immediately above) winner of this year's John A. Dorr Award.

Steve Kesler served as Thayer Lindsley Lecturer for the Society of Economic Geologists this year. Thayer Lindsley was a prominent mine finder, whose bequest supports a lecture series for schools and other groups interested in mineral deposits. Steve met Thayer Lindsley, then in his late 80s, while passing through New York in 1963 to begin thesis work in Haiti. The lecture tour included Universities of Missouri and Utah in the U.S., Alberta (Canada), Geneva (Switzerland), Orleans (France), and Cardiff (U.K.), and geology-exploration groups in Salt Lake City and Yellowknife, Canada. Following up on his long-term interest in the geology and mineral deposits of the Caribbean, Steve began a research project on gold mineralization in Cuba, financed by Canadian mining companies (U.S. funds cannot be used there) and reported preliminary results at the U.S.G.S. Cordilleran Exploration meeting in Reno in April, 1995. At home, Steve and **Joe Graney** completed a chapter for the short course on Magmas, Fluids and Ore Deposits at the GAC/MAC meeting in May, which Joe will be attending, and **Angela Briethaupt** joined the Ore Deposits Laboratory, in charge of fluid inclusion and other research equipment. On the teaching front, Steve worked with **Phil Meyers** and **Jim O'Neil** to start Environmental Geochemistry, which was taught to 20 students in the Winter term. The big news, however, was that Steve rotated off the NSF Geochemistry and Petrology panel after three years, just in time to write some new proposals for renewed funding.

After a burst of papers on sedimentation, stratigraphy, and the history of melt water flow through the Great Lakes, **Ted Moore**, **Dave Rea** and colleagues from the University of Minnesota and Kent State University have been funded for a continuation of this project. They will be going to the inland seas this summer on board the University's research ship, the Laurentian, for three weeks of high resolution seismic reflection surveying and piston coring. They will be accompanied by co-workers from the Canadian Geological Survey and an entourage of graduate students eager to be indoctrinated into the nautical ways of surveying and sampling. One of the surprising findings of the first phase of their work was that there were isotopically light waters (melt waters) in northern Lake Huron as recently as 7200 years ago. Conventional wisdom had previously held that melt water drainage from the last remnant of the Laurentide ice sheet was all directed into Hudson Bay by 8500 years ago. During this summer's trip they hope to sample the proximal areas of North Channel, Georgian Bay, and Northern Lake Huron to verify this initial finding and try to determine whether the source of these isotopically light waters was from glacial Lake Agassiz or Lake Barlow-Ojibway. They will also survey the Whitefish Delta, first recognized back in 1955 in northern Lake Michigan at about 60-90m present-day water depth by U-M Professor **Jack Hough**. Jack did not have the advantage of precise navigation and high resolution seismic gear that is available today. Dave and Ted plan to use these new tools to help define the history of this delta which was fed from Lake Superior through the Whitefish channel that cut across the central Upper

quality which can stand for decades, and she has the patience and tenacity to do that. Second, you should have the courage to be wrong if you wish for the satisfaction of being right. She developed that courage in spades, because an unknown, unused and amorphous strength became honed on her research advisor, who was not always inclined to submit (even when wrong) without a contest.

Zachary D. Sharp
wins MSA Award

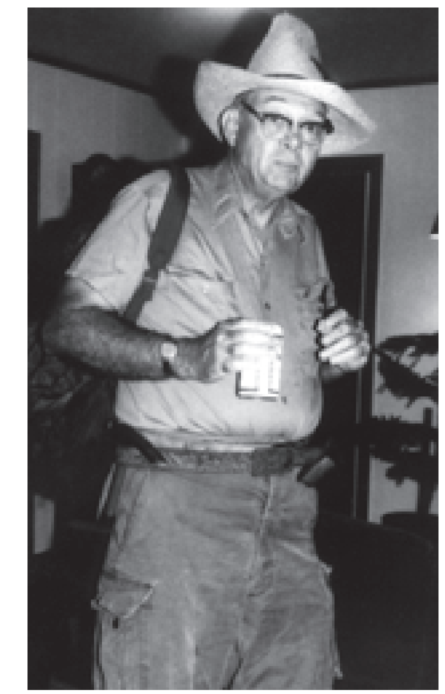
Zach Sharp (MS '84, PhD '88) is this year's recipient of the Mineralogical Society of America Award given to an outstanding young mineralogist/petrologist. Zach got a BS degree at the University of California in 1982 and worked for a year as geologist for the BART tunnels in the Bay Area. He got a MS degree in 1984 with **Bill Kelly** and **Eric Essene** for a study on the petrology of arsenopyrite assemblages, and a PhD in 1988 working with **Jim O'Neil** and Eric Essene. His PhD was on stable isotope and petrologic studies of granulites from the Wind River Range in Wyoming. He was a notable field camp TA and very active in the department. Zach took a postdoctoral fellowship at the Geophysical Lab in Washington, D.C., working with Doug Rumble, where he set up one of the first successful laser oxygen isotope systems with the help of an NSF grant that he wrote. He is a Research Faculty member at the University of Lausanne where he has built an impressive stable isotope facility with laser sampling. Zach has now established himself as one of the preeminent stable isotope geochemists in the world. Congratulations, Zach!

Damon Teagle
wins Sokol Award

Damon Teagle (U-M Postdoctoral Fellow) has been awarded a Sokol Postdoctoral Fellowship. This relatively new award is a very competitive U-M fellowship. Only one is awarded per year as a result of a competition with current postdocs from other science departments. Damon did his PhD at Cambridge University with Mike Bickle and Ron Oxburgh studying isotopic studies of fluid flow in the Troodos Ophiolite. He is currently working with **Jeff Alt** on alteration of the ocean floor. Damon was selected from the current postdocs in our department and competed with applicants selected from the best current postdocs in each of the science departments, notably Physics, Chemistry and Biology.

James Lee Wilson
wins AAPG Award

James Lee Wilson, a former U-M faculty member is the recipient of the 1995 Distinguished Educator Award of the America Association of Petroleum Geologists. In his citation Neil F. Hurley writes "Jim Wilson and his incredible wife, **Dell**, have earned the love of every student whose lives they have touched. There can hardly be two human beings who have provided more encouragement, support, sense of humor, and positive outlook to undergraduate and graduate students alike."



Jim Wilson came to the University of Michigan in the winter of 1979 from Rice University where he held the Keith Weiss Professorship in the Department of Geology. Jim Wilson brought to our department a refreshing and experienced perspective developed over a long professional career in the earth sciences. As an undergraduate, he studied at Rice University and the University of Texas. He received his PhD from Yale University in 1949. Jim Wilson is widely known as one of the world experts on carbonate stratigraphy, and he has been the academic advisor to an impressive number of leading carbonate research geologists working around the world today. To his students he provided professional direction, support and a sense of humor. He retired from the University of Michigan in 1986 and has been leading a very active life in New Braunfels, Texas, as a private consultant since that time.

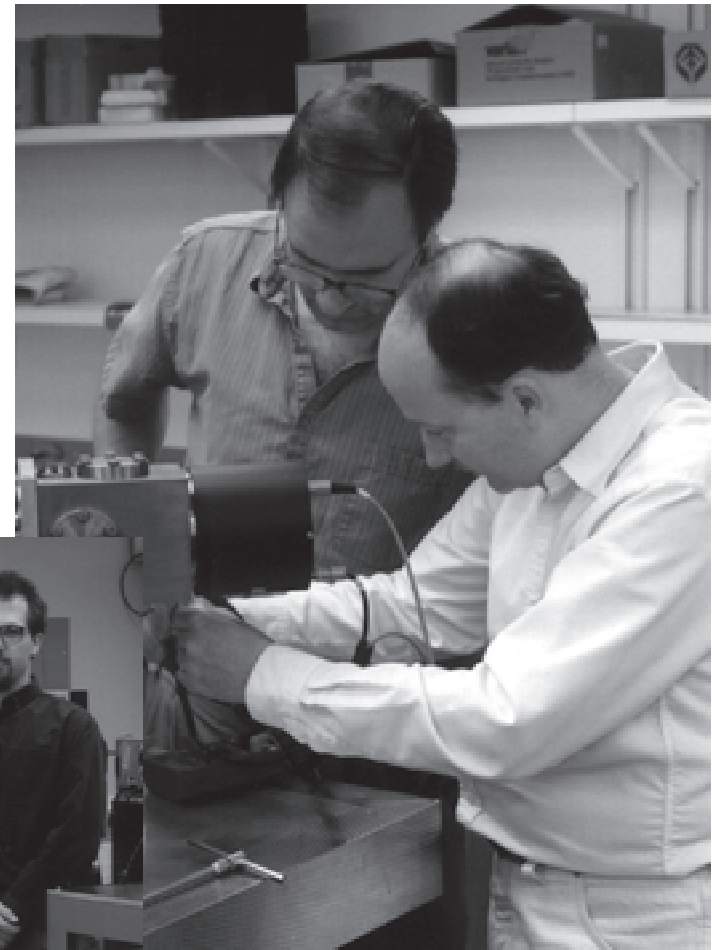
Jim Wilson was president of SEPM in 1975-1976, became an Honorary Member in 1980, and is a holder of the Twenhofel Award. With AAPG, he has done extensive committee work, was an associate editor from 1975 to 1981, and was elected to Honorary Membership in 1987. He is a member of numerous geological societies and regularly participates in carbonate symposia, field trips, and lecture courses.

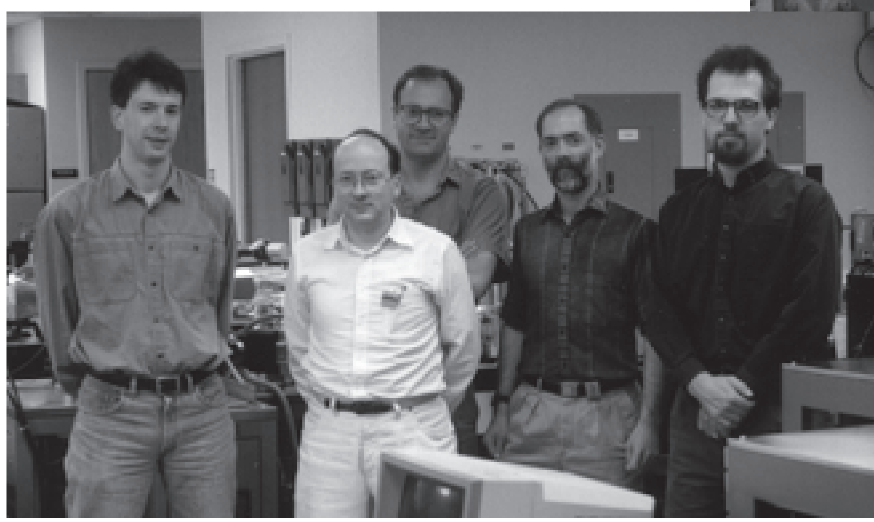
It is with fond memories that we extend our congratulations and best wishes to Jim upon the receipt of this fitting award.

New Noble Gas Geochemistry Laboratory

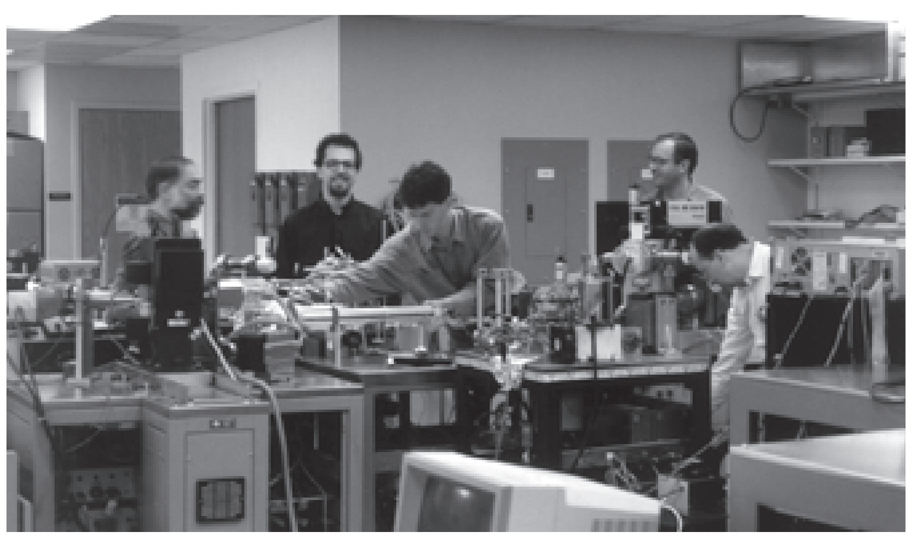
In the midst of all the noise, dust and rubble of building renovation that has devastated C.C. Little over the past year, we have built a new laboratory for noble gas isotope geochemistry which is now fully occupied and engaged in an exciting new research program.

The Radiogenic Isotope Geochemistry Laboratory (RIGL) has expanded with the acquisition of two additional noble gas mass spectrometers in addition to the new multiple collector ICPMS.





The current team of "NoGGLers" (l-r); Chris Ballentine, Chris Hall, Alex Halliday, Marcus Johnson, and Dan Barfod.

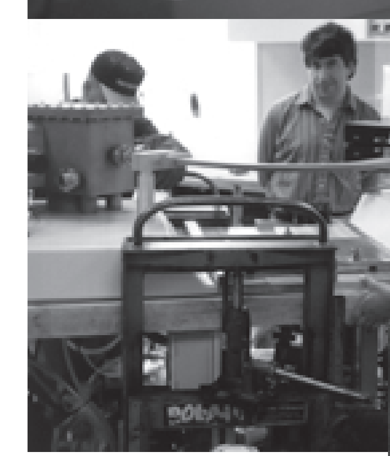


The noble gas geochemistry laboratory (NoGGL?) is housed in newly renovated separate space next to the RIGL (see photo) and now contains three mass spectrometers and a variety of extraction and gas cleanup systems including a laser microsampling facility. This is being developed to enable the study of natural rare gas isotopic compositions in a variety of samples ranging from fluid inclusions to plume-derived basalts. The financial support for this facility has come from the Department, the Shell Foundation, the College of LS&A, the Office of the Vice President for Research and the National Science Foundation. **Dr. Chris Ballentine** is a new Assistant Research Scientist in the Department and his background in studying rare gas geochemistry of fluids from hydrocarbon reservoirs is ideal for much of the research that will be developed at U-M, as explained in the following article.

Dan Fisher's successful completion of the casting of the Brennan mastodon trackway, last fall, was followed this winter by installation of a portion of the cast in the Exhibit Museum. Additional supporting display material remains to be developed, but it is gratifying to have a major portion of the project much nearer to completion. Much of Dan's time this winter was devoted to the search to fill the open faculty position in invertebrate paleontology. In addition, he gave two symposium presentations at the annual meetings of the Society for American Archaeology, the GSA of Archaeology. These covered aspects of his mastodon and mammoth work, which also wound up on the cover of an issue of the Chronicle of Higher Education and in a film put together by a BBC crew for a science news program called "Tomorrow's World." Meanwhile former graduate student **Brian Bodenbender** was selected for a highly competitive University postdoctoral fellowship at Ohio State, and has been using his remaining time here to get papers submitted from his dissertation work and complete various collaborative projects with Dan. **David Fox** has found exquisitely preserved incremental features in tusks of Miocene gomphotheres, confirming the feasibility of extending a proboscidean-mediated record of climate change back into the Tertiary, and **Talia Sher** has been experimenting with new analytical techniques for resolving sexual dimorphism in proboscideans.

Chris Hall writes that the argon geochronology lab has gone into a quiescent phase because of the move into the expanded portion of the RIGL lab. After some clay analyses by **Hailiang Dong** and some Grenville province runs by **Jay Busch** in late 1994, the system was shut down in preparation for the move. Both argon mass spectrometers and their associated fusion systems have been set up in the new lab space. With only a few bits of unwanted excitement, the move has gone remarkably smoothly. The two argon machines have now been joined by the VG-3000 which will specialize in measuring helium. The lab should soon be an integrated noble gas measuring facility. Work is under way to expand the software capabilities of both the MAP-215 and VG-1200S machines. This will allow us to shift the bulk of the argon dating work to the VG-1200S which will free up the MAP215 for work on the heavier noble gases. This work will be spear headed by **Chris Ballentine** (see article in this issue). Control software for the laser system connected to the Plasma-54 mass spectrometer has been developed. This software can learn complex curves and then generate a smooth laser ablation track. We practised by performing "plastic surgery" on Abraham Lincoln's nose (on a penny) and then moved on to trying out tracks on pieces of mollusk shells.

Alex Halliday says things have never been better in the field of radiogenic isotope geochemistry at U-M. New technique developments and lab expansion have dominated much of the activity in the Radiogenic Isotope Geochemistry Lab over the past six months. The noble gas geochemistry lab expansion is discussed elsewhere in this issue. The development of MC-ICPMS is going even better than expected. Our new measurements of tungsten isotopic compositions in meteorites, a principal research effort of postdoctoral fellow **Der-Chuen Lee**, are providing powerful new constraints on the history of accretion and planetary core formation in the inner solar system. Graduate student **Wen Yi** has made the most accurate



Moving the new inductively-coupled plasma magnetic sector multiple collector mass spectrometer into RIGL went smoothly thanks to cordial collaboration of members of the department, Plant Operations, Fisons Instruments, and the building contractor Ellis-Don.

Faculty, Research Staff, and Student News

Last fall, **Jeff Alt** spent two months in the middle of the Atlantic Ocean on Ocean Drilling Program Leg 158. This project drilled several holes into the TAG hydrothermal mound, an actively forming massive sulfide deposit with black smokers emitting 350°C fluids. This is the largest massive sulfide deposit known on unsedimented mid-ocean ridges, and it is the first time that an active black smoker complex at a mid-ocean ridge has been drilled. Jeff and post-doc **Damon Teagle** will be studying cores of the mineralized stockwork feeder zone beneath the deposit. Jeff was a co-convenor of a RIDGE workshop on Global Impact of Submarine Hydrothermal Processes, in Boulder, Colorado, last fall, and then, in what seems to be becoming an annual trip, had another chance to visit Hawaii this winter, where he got hot feet walking on a cooling lava flow. The experience of sampling molten lava with a rock hammer was only surpassed by having a picnic dinner in the dark, lit by streams of red lava cascading down a cliff and into the sea.

Catherine Badgley has been busier at the computer than in the field over the last couple of years. She and **Kay Behrensmeyer** co-edited a special issue of *Paleogeography, Paleoclimatology, Paleoecology* due out in May, 1995. The special issue, entitled "Long Records of Continental Ecosystems: Paleogene of Wyoming-Montana and Neogene of Pakistan," presents comparison of the geological, paleoclimatological, and paleontological records of two well documented Cenozoic vertebrate records; several of the 14 papers address issues of vertebrate taphonomy, paleocommunity ecology, and the reciprocal interactions of ecology and evolution. **Serge Legendre**, **Catherine Badgley**, and **Philip Gingerich** will finish their collaborative survey of size structure (through cenograms) of modern mammalian faunas in relation to climatic conditions this year and will submit a book manuscript (*Mammals, Size, and Climate*) to the University of Chicago Press.

Enriqueta Barrera was a convener of the Cushman Foundation symposium at the annual meeting of the Geological Society of America in Seattle. Speakers, including **David Dettman** (PhD '94), addressed various aspects of the Late Cretaceous marine and continental record of global climate change. These contributions will be published in a GSA book that she is editing with another colleague. In the meantime, she continues to investigate the global climate and oceanography during the Campanian and Maastrichtian using biotic and geochemical proxies. She and **Kacey Lohmann** participated in a two-month cruise of the Ocean Drilling Program to investigate the evolution of the transform continental margin in the eastern equatorial Atlantic. They will study the diagenetic evolution of drilled Tertiary and Cretaceous sediments.

Eric Essene just completed the annual downtown/campus walk with the GS310 students and is currently preparing final exams for Petrology and Analytical Methods. He participated with **Sam Mukasa** and many other faculty at "spring" break in preparing a major NSF proposal for a Cameca 6f SIMS to be housed in EMAL. It will be nice to measure trace elements in zoned metamorphic minerals such as garnet, epidote and monazite. Eric is presenting a paper with **Don Peacor** at the spring *Goldschmidt Conference* on the fallacies inherent in clay mineral thermometry, and they have a paper in press to *Clays & Clay Minerals* on this subject. With **Donggao Zhao** (PhD student), Eric is planning a trip to China this June to examine and collect high-pressure assemblages brought up in diamondiferous kimberlites. He also hopes to spend a week or so in the Wind River Mountains this August with **Steve Keane**, a new grad student from USC.

Therapy proceeds with son Zach, who continues to show improvement. Zach is very excited about his weekly horse-riding, which has just started, but he really wants to be an astronaut. Writing of Zachs, all had a great time last month when **Zach Sharp** (PhD '88) visited Ann Arbor as a Turner Lecturer. Adam recently hurt himself jumping off a jungle gym. The plus side was that he was able to proudly limp around with crutches and a soft cast for a week or so, acutely reminding his father of his own past breaks at MIT, Berkeley and Canberra. In February Eric visited **Dex Perkins** (PhD '79) and his family while giving lectures at the University of North Dakota. Dex and Betsy are very visible both in academic and community activities in Grand Forks. While stopping off to see Michelle in Minneapolis on the way home, Eric made the mistake of downhill skiing with cross-country skis. He sliced his thumb open on the skis during a bad fall and spent the rest of the day getting the thumb put back together at the University of Minnesota Hospital where Michelle is a second year medical student. So what else is new? The rest of the family is fine.

Bill Farrand has survived the big coming-out party in the Exhibit Museum. On March 31 through April 2 the Museum unveiled its new dinosaur and held an open house to show off the new decor of the Hall of Evolution. Some 3500 sponsors and visitors came through the Exhibit Museum in a 48-hour period, exceeding the greatest expectations of the Museum staff. The "Buy-A-Bone" campaign brought in some $33,000 from the dinosaur-hungry public. **Dan Fisher**'s mastodon trackway and **Larry Ruff**'s "Make-A-Quake" interactive seismology exhibit were previewed on the same weekend. "Make-A-Quake" will be fully functional by September, and the complete trackway will be in place within a month or so. Also, in the Museum Rotunda, there is a display of exceptional fossils expertly prepared by the Friends of the Museum of Paleontology. Otherwise Bill is busy with national and international Quaternary activities. He will be representing the United States National Committee at the International Quaternary Congress (INQUA) in Berlin in August, with a stop-over in Crete to map an archaeological site. Closer to home, he is presiding over plans for the next American Quaternary Association (AMQUA) biennial meeting to be held in Flagstaff a year from now.

Noble Gases, Hydrocarbon Reservoirs and Crustal Fluid Transport

by Chris Ballentine

Whether we are looking at a minute quantity of fluid trapped as an inclusion in a mineral or an entire hydrocarbon reservoir, we can use the distinct isotopic structure of the noble gases to identify and quantify the noble gas contributions from mantle, crust and atmosphere-derived sources (Figure 1). Noble gases from these sources are intimately associated with major fluid species, and can give us direct information about the origin of the fluid. For example, at mid-ocean ridges (and hotspots) CO_2 and ^3He are degassed at a near constant ratio. Similar $CO_2/^3He$ ratios observed in regions of continental extension provide strong evidence for a magmatic (mantle) CO_2 origin, information not available from carbon isotopic systematics alone. Similarly, methane (CH_4) gas which has been transported as a dissolved phase in groundwater, on degassing gives a characteristic $^{36}Ar/CH_4$ ratio, determined by the ^{36}Ar concentration fixed in the groundwater at recharge and the temperature/salinity of the groundwater during degassing.

Where these relationships are not preserved due to, for example, loss or addition of major fluids to the system, the noble gases still provide a conservative tracer of the volumes of these differently sourced fluids which must have at some stage interacted with the system. For example, it has been shown that in the Pannonian Basin, Hungary, tens to hundreds of cubic kilometers of groundwater must have been involved in the transport of natural gas into one trapping structure alone. In the same system the quantity of noble gases derived from crustal sources (through the natural decay of U, Th and K in the crust) requires long term build up and storage of these radiogenic noble gases within the deep crust, with subsequent release probably resulting from the increased thermal gradient and metamorphic fluid expulsion during basin extension.

Although they act as a conservative tracer of these processes, the elemental abundance pattern of the differently sourced noble gases are sensitive to different physical fractionation processes. For example, elemental fractionation between different subsurface phases, caused by the different relative solubilities of the noble gases in each phase, is quite distinct from elemental fractionation caused by a mass fractionating diffusional process. The identification of these patterns enable constraints to be placed upon the subsurface processes operating on the noble gases, and by inference the related major species. By identifying a similar (or lack of) fractionation in differently sourced noble gases one can also constrain the importance/magnitude and relative timing of a particular fractionating process.

Work underway in the new U-M noble gas laboratory addressing crustal fluids includes the characterization of mantle-derived noble gases in continental environments. Although it is well established that mantle-derived volatiles are associated with continental extension, it has only recently been noted that the He/Ne ratios of this component are more similar to those observed at hotspots rather than mid-ocean ridges. This type of study will play a part in our understanding of the role of plumes in continental rifting and, given the more volatile rich-nature of plumes, may change our understanding of the nature and magnitude of magmatic volatile input into basin systems.

A relationship between nitrogen and helium concentrations has been observed in many natural gas deposits, most notably that in the Texas Panhandle. It would appear that both the nitrogen and helium originate from the deep crust. A detailed study of the crustal radiogenic noble gases and nitrogen isotope systematics in these systems will provide us with invaluable information regarding the mechanism of metamorphic-derived fluid release and transport from deep regions of the crust. More broadly, comparison with nitrogen-rich systems containing little helium will help constrain the relative importance and physical processes by which differently sourced nitrogen is introduced to sedimentary hydrocarbon-rich systems.

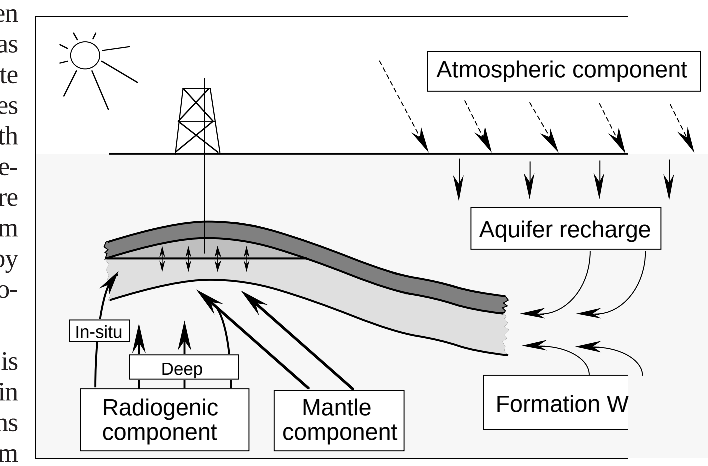


Figure 1. The distinct elemental and isotopic compositions of noble gases derived from crust, mantle, and atmosphere-derived sources enables their contribution to any fluid to be resolved and quantified.

The role of differently sourced fluids in mineral formation processes is also a topic which may be addressed by noble gas studies. Samples in which fluids are trapped, however, often contain two or more generations of fluid inclusions. We are currently developing a laser ablation system that will enable us to determine the noble gas composition of fluid trapped within individual inclusions or groups of inclusions of the same generation.

Chris Ballentine is an Assistant Research Scientist in the Department.

Alumni News

1940's

Nancy Thomssen Rabe (BS '46) writes from Phoenix AZ that she is enjoying her retirement by golfing and doing lots of traveling.

Lawrence E. Mannion (MS '48) is retired to the San Francisco Bay area, which he believes to be the best climate in the world. He is trying to write and carve stone, among many other things. He was chief geologist for Stauffer Chemical Co. until 1986 and retired just before Stauffer was sold and broken up. During his 32 years the first half was mineral oriented, and the second half was environmental, engineering, ground water, etc. He managed to locate the shallowest trona in Wyoming in 1959.

Waldemere Bejnar (MA '48) writes from Socorro NM that in his retirement he has a rock shop. He cuts and polishes a lifetime's collection of rocks and sells some at craft fairs. He also farms and plays tennis.

1950's

John W. Keeler (MS '51) lives in Scott LA. He is a member of a partnership (BKD) which is involved in the development and sale of land tracts in Cameron County, Texas.

William K. Easton (MS '52) and his wife joined an ice hockey and cultural tour of St. Petersburg, Moscow, and Amsterdam in the winter. They say it was an unforgettable and unbelievable experience and recommend it highly.

Chesley C. Herndon, Jr. (MA '52) tells us that the beauty of petroleum geology is that you are never forced to retire but can continue to pursue your lifetime occupation, hobby and passion until you go to meet "that Great Rockhound in the Sky."

Curtis L. Lundy (BS '54, MS '58) retired on June 1 from Michigan Consolidated Gas Co. after 32 years. He is planning to travel through the summer and autumn, with weekly sailboat races on Lake St. Clair and the Port Huron to Mackinac race in July. Curt says "Retirement is great—you get twice the amount of life at half the income!"

1970's

Roger L. Gilbertson (PhD '72) has moved back to Houston from Buenos Aires, Argentina, which they miss greatly. After five years it was certainly home. George C. McIntosh and Roger still stay in touch — there are Devonian crinoids in northern San Juan Province after all. He is looking forward to more travels in Latin America, especially the Altiplano of Bolivia. "Best wishes to all in 1995!"

Wendy Gordon Sheridan (MS '79) worked for Exxon Co. USA 1979-1986. She then went to Riverside County CA Health Dept. 1989-91. Their daughter was born in May 1991. Her husband was transferred to Oklahoma at that time. There were no job opportunities for Wendy in Ardmore, but she was Secretary-Treasurer for the Ardmore Geological Society 1992-94. Her twin sons were born in October 1994, so she is staying entertained by juggling twins and a pre-schooler. She wants to get back into environmental work when they leave Ardmore, which hopefully won't be too far off.

1980's

Teresa S. Czarnik (BS '84) and husband Tim went camping in and around Olympic National Park in northwestern Washington state and comment on the spectacular pillow basalts in the area. At Geophysical Fluid Dynamics Laboratory (GFDL) Teresa is researching sources which may provide dated temperature estimates during the last glacial maximum, which includes surfing the WWW.

James L. Folcik (MS '84) and wife Nancy are proud to announce the birth of their second child, Lindsey Paige, on February11, 1995. Things went great as they made it to the hospital 30 minutes before the birth. Lindsey joins her brother Jared who is $2\frac{1}{2}$ and already hooked on Bill Nye the science guy. Class of 2014?

Bryan E. Stepanek (MS '84) writes from Anchorage that he and his wife are enjoying their first child, Rachel, who was born in April 1994. She is 20 pounds of redheaded willpower.

Gale D. Martin (BS '80, MS '85) tells us that she has been living in Las Vegas for five years now. She escapes from the summer heat every year by traveling the states from coast-to-coast (Washington DC to Eureka CA last year. She is now a full tenured professor for the university and community college system of Nevada. Gale enjoys the wide variety of geology in the valley, especially since there's no "green stuff" in the way. Don't sit down without looking for cactus needles, though. She bought a new home in Henderson and already had an earthquake roll through from the River Mountains behind the house on January1—welcome to the new year!

Simulating Plume Penetration at the 670 km Discontinuity

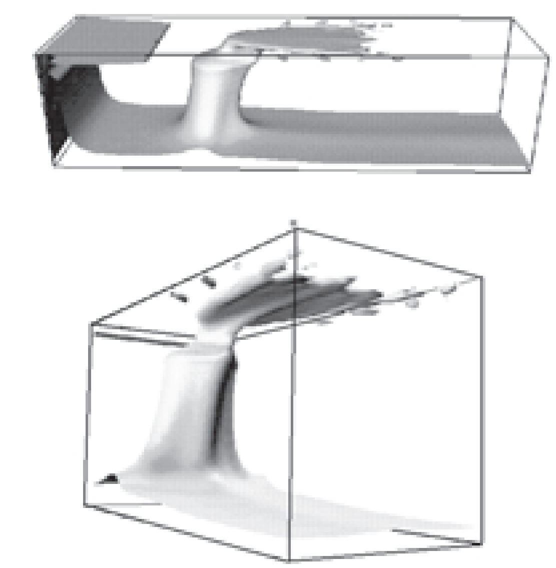
by Peter van Keken

An outstanding problem in geodynamics is the source of hotspot volcanism. It has long been agreed that hotspot activity is caused by localized upwellings from the deep mantle. These "plumes" impinge on the lithosphere, creating present-day uplift and volcanism, with Hawaii as a prime example. The geologic history of the plume can be traced in the hotspot trail, the linear trace of islands and seamounts, caused by now extinct volcanism. Although this cartoon view is attractive, it poses many questions regarding its dynamical feasibility: How can the plume source survive for many tens of millions of years? If the lower mantle is convecting, why is it that the plume source does not seem to shift its location in the mantle, whereas the oceanic lithosphere moves (from a geological point of view) at high speed? How does the plume interact with the thermodynamic and rheological properties associated with the discontinuities in the upper mantle transition zone?

In order to investigate possible answers to these questions, Peter van Keken has developed dynamical plume models in a collaborative effort with Carl Gable (Los Alamos National Laboratory), David Yuen (University of Minnesota) and Arie van den Berg (University of Utrecht, The Netherlands). The main focus is the possible rheological changes that occur across the 670km discontinuity. Although the experimental and theoretical evidence for slow creep of mantle silicates under high temperature and pressure conditions is limited, it is likely that the viscosity in the lower mantle increases with depth. In addition, it is possible that the creep mechanism changes, from dominantly non-linear dislocation creep in the upper mantle, to linear diffusion in the lower mantle. Based on these assumptions Van Keken and co-workers have constructed a model in which a plume rises through a high viscosity lower mantle and penetrates the 670km discontinuity and the lower viscosity upper mantle. The evolution of this model is described by basic physical conservation laws, from which equations can be derived that are in this case solved by numerical methods. The figure shows an example of a three-dimensional model of such a plume. The model represents the mantle of the Earth with a thickness of 3000km. The 670km discontinuity resides at approximately one quarter of the distance from the top of the model.

A shaded surface that indicates a constant temperature of approximately 2000K can be seen. Below this, surface temperatures are higher. At the left hand boundary the ridge-like feature indicates an upwelling of hot mantle material that could be thought to represent a mid-ocean ridge. In the center of the model a more or less cylindrical plume wells up from the lower mantle. The high viscosity in the lower mantle gives the appearance of a rather "bulky" plume. The plume changes its character as soon as it enters the lower viscosity region above the discontinuity. The hot upwelling material achieves a higher viscosity here, which effectively thins the width of the plume. As it reaches the bottom of the strong lithospheric plate, the plume is advected by the plate motion. As the hot material moves downstream, it spreads in a typical parabolic shape.

In several other models it has been observed that the plume penetrates the upper mantle in a time-dependent manner. The higher speed achieved in the upper mantle causes the hot material to separate from its source. The hot material then impinges on the lithosphere as a discrete diapir, which is later followed by other diapirs, shed off the 670km discontinuity, fed by the slow upwelling in the lower mantle.



This research has produced explanations for two important observations. The first concerns the stationary nature of hot spot trails with respect to lithospheric motion, which can now be explained by the high viscosity of the lower mantle. The second observation is the episodicity of hot spot volcanism, such as is seen under Hawaii and the Cameroon line in the Gulf of Guinea. This fits nicely with the numerically modelled diapirs.

Models like these help to give a better understanding of mantle convection and plume dynamics and their role in plate tectonics.

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