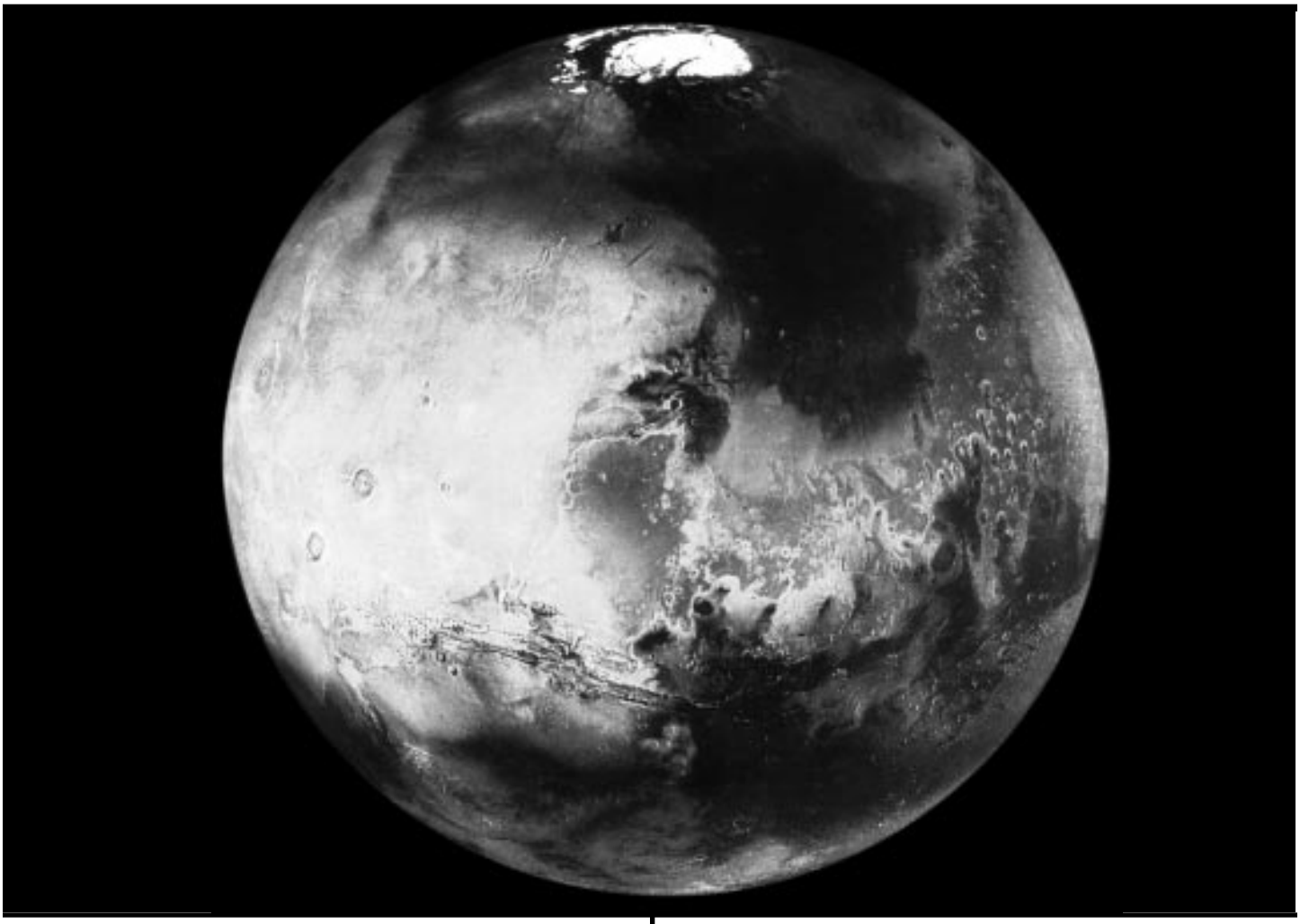
GEOSCIENCE NEWS

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

December 1996



Life on Mars?

Meteorite evidence for life on Mars discussed by Allan Treiman (photo courtesy NASA) *See page 3.*

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In this Issue:

Greetings from the Chair

Dear Friends of the Department:

I am writing this letter just a few weeks after the annual meeting of the Department of Geological Sciences Alumni/ae Advisory Board. After my second board meeting as chair, I have come to recognize the truly great service that board members render to the department. The members normally serve for five years each, so every year there are usually two new people coming to Ann Arbor in October. At every meeting the board is updated on departmental happenings during the previous year, especially matters of curricula and personnel. The board as it is now constituted has four representatives from larger energy companies, two representatives who run their own environmental companies, two faculty members from other universities, and one federal employee. They provide to us a sounding board for discussion of what is going on in the department, feedback on our plans for new courses or programs, and insight to employment trends - the sort of a reality check that those of us in academia need every now and then. Further, the board members help the department in significant ways with our development program. In fact, in the coming months you all will be hearing from the outgoing board chair, John Joity, on the topic of annual giving.

Board members arrive in town on Thursday evening, meet all day Friday, have the option of going to the football game on Saturday (Indiana this year) and usually return home on Sunday. Thus their commitment to the department requires three or four days every fall, in addition to doing some homework. In order for board members to become better acquainted with us and our concerns, the department organizes three social gatherings for faculty and students to mingle with the board members and converse one-on-one. All this makes for a high-energy few days for the board members. The department and its graduates owe them a big debt of gratitude.

In other departmental news, I am delighted to report that the College has committed $100,000 for long-overdue repairs and maintenance needed at Camp Davis. This decision is the result of an approximately two-year effort by the department and two of our alums to bring the educational program at Camp Davis and the state of its facilities to the attention of the Dean. The final impetus for this decision was a visit by the college's facilities manager to Camp Davis late last summer - to see for himself what we were talking about. Next year we hope to get the LS&A Associate Dean for Education to Wyoming to see how the 116 and 440 classes are run.

I am beginning to feel almost obliged to add a short paragraph about construction progress to these letters. The next significant project in the building is expected to begin during the winter semester. It is to renovate the south end of the second floor of C.C. Little and build laboratories for the research scientists of the Center for Great Lakes and Aquatic Sciences. Their offices will be in the Dennison physics building, connected by a bridge to the second floor of C.C. Little. CGLAS is an LS&A research unit that has close ties to geology, biology and natural resources and is being moved from North Campus to Main campus to enhance those intellectual ties. Although it will not be our project to keep a close watch on, it will result in the many little (sometimes not so little) disruptions that we have become familiar with over the past three or four years.

The reception for Michigan alumni/ae and friends at the Denver Geological Society of America Annual Meeting was well attended (as was the meeting in general with over 6600 registrants). We were delighted to welcome and chat with department graduates of five decades, extending back to the 1950's. Next fall the GSA meeting will be held in Salt Lake City. I hope to see many of your there.

Sincerely yours,

David K. Rea

David K. Rea

Professor and Chair

Life on Mars?

Allan Treiman (PhD '82) provides a well-informed perspective on Martian meteorites

Allan Treiman explains the meterorite to schoolchildren.

Eric Essene used to rail at typical petrology labs, calling them "rocks in boxes." Orphan samples ripped from their outcrops, exiled from their settings, oblivious to their entire geologic contexts. Rocks without the world that surrounded them. (These aren't Eric's words; he was more pithy.)

Meteorites are the ultimate "rocks in boxes." They come to us from space without outcrop maps, without guidebooks to their region, and even without labels saying where they're from. The challenge of meteorites is to reconstruct a geology, a history, and even a planet or asteroid from a single rock or a few related rocks. Generally, much of a geologic history can be reconstructed, but only by thoughtful integration of all available data: petrologic, geochemical, isotopic, and astronomical.

Martian meteorites are hot items now, since David McKay (of Johnson Space Center) and co-workers claimed to have found microfossils and organic trace fossils in one of them, ALH 84001. But how could anyone know that the 'martian meteorites' are from Mars? How could the rocks have left Mars and come to Earth? And are these fossils for real?

Meteorites from Mars? The claim that some meteorites come from Mars was first suggested in 1979, and is now generally accepted in the profession. Backing up a bit, meteorites come in three basic varieties: iron, stony irons (mixed iron and silicates), and 'stones' or silicate rock meteorites. Most of the stony meteorites are chondrites, composed of millimeter-sized spherules of silicate minerals, and a small proportion are achondrites, a fancy word for igneous rocks. Most achondrites are basalts or breccias of basalt fragments, and look very much like Earth basalts.

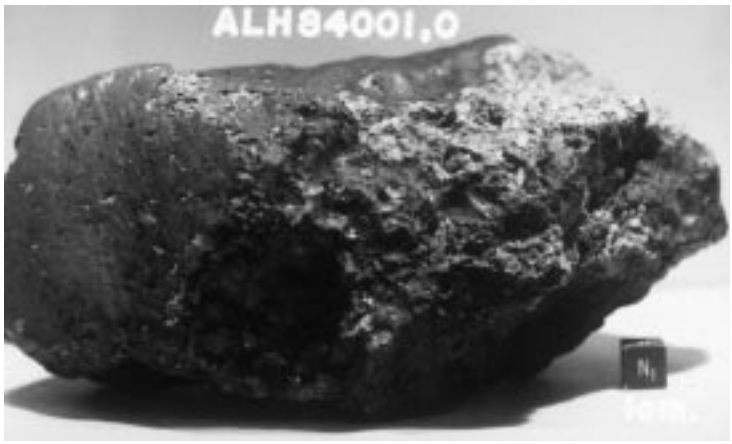

Figure 1. ALH 84001 meteorite, as it appeared before dissection. Cube is 1 cm on a side. Note black glassy fusion crust covering meteorite.

One small group of about ten achondrites, or basaltic meteorites, stood out from the rest. These meteorites were informally called SNCs, an acronym after three characteristic meteorites in the group, Shergotty, Nakhla and Chassigny (Figure 1). Chemically, the SNCs are rich in moderately volatile elements (e.g., Na, K) compared to other achondrites and even compared to most Earth basalts. The SNCs also have strongly fractionated rare earth element patterns - suggesting a complex history of igneous processing. But their crystallization ages are extraordinary; they crystallized from magma at 1.3 Ga to 180 Ma, while all other meteoritic materials formed much earlier, most at 4.5 Ga!! These young crystallization ages seem inconsistent with an asteroidal origin, and more characteristic of a large, volcanically active planet. Oxygen isotopes and geochemical clues (K/U, Mn/Fe, Na/Al, Ga/Al) proved that the

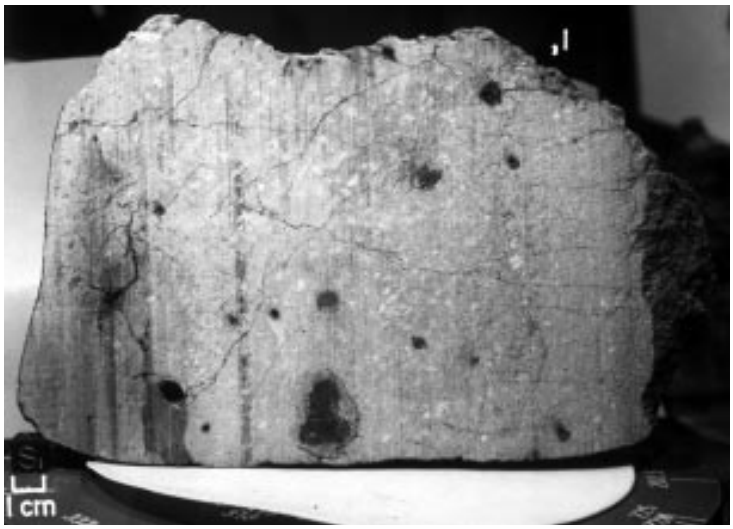

Figure 2. Sawn face of EETA 79001 martian meteorite. Vertical stripes are kerf marks from sawing. The black spots and streaks on the surface are pools and veins of shock glass, which contain the martian atmosphere gas.

SNCs were not merely Earth rocks that somehow got into space (as tektites did). Their compositions were similar to Mars' soil, as analyzed on Mars by the Viking Lander spacecraft. As early as 1979, there were serious suggestions that these SNC meteorites came from Mars.

The strongest evidence that the SNCs are from Mars came from gas analyses of an Antarctic SNC meteorite, EETA 79001. EETA 79001 contains veinlets of glass formed by intense shock event (Figure 2), and Dr. D. Bogard of the Johnson Space Center tried in 1982 to find the age of the shock by potassium-argon (actually $^{40}Ar/^{39}Ar$) dating. Taking his data at face value yielded an age of >6 Ga, rather unlikely in a rock that crystallized at ~1.3 Ga. This unexpected result pointed to 'excess' ^{40}Ar that did not come from decay of radioactive potassium in the rock. Coincidentally, analyses by the Viking Lander spacecraft, on Mars, had shown that the martian atmosphere is very rich in ^{40}Ar. After repeated analyses, Dr. Bogard showed in 1983 that the isotopic composition of the excess argon in EETA 79001 was essentially identical to the argon in the martian atmosphere. Since then, his work has been extended to elemental and isotopic abundances of nitrogen, neon, krypton, and xenon (Figure 3); within error, the martian atmosphere and the EETA 79001 gas are identical. All of the martian meteorites contain traces of this gas component.

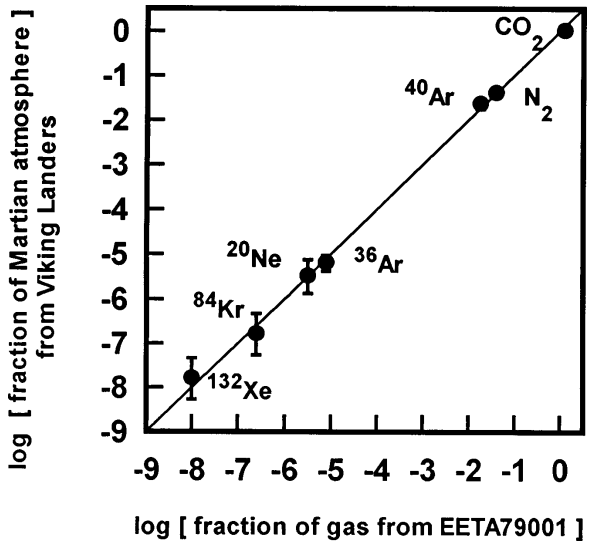

Figure 3. Composition of trapped gas in EETA 79001 shock glass, compared to composition of Mars atmosphere, measured by the Viking lander spacecraft.

The identity of the EETA 79001 gas and the martian atmosphere might mean nothing if that were a common gas composition in the solar system. So far, however, it is singular. The composition of the martian atmosphere seems to be a unique product of early planetary differentiation and outgassing modified by extensive loss of light isotopes to space. No other gas component identified in a planetary atmosphere or meteorite could be confused with the martian atmosphere. In absolute fairness, none of this constitutes absolute proof that the SNC meteorites are from Mars. But the case for a martian origin is very strong — where else could they come from?

Come to Earth? The next question, once you accept that the SNC meteorites are from Mars, is just how they got off Mars. How could a solid rock be propelled off the Mars' surface faster than its escape velocity, about 5 km/sec? The only process with enough energy appears to be meteorite impact — volcanic explosions seemingly can't throw rocks fast enough. In effect, a small asteroid striking Mars can impart enough of its energy to surface rocks to expel them from Mars' gravity. This conclusion was controversial, as experts stoutly claimed that the impact excavation of a crater could not accelerate solid rocks to 5 km/sec, only rock vapor. The dispute subsided with the recognition that a separate process, spallation, could accelerate solid rocks away from the impact site to sufficient speeds. Shock impact also provides an easy mechanism for trapping martian atmosphere in the meteorites. Experiments have shown that gas in fractures in a basalt is trapped during impact shock as the fractures are slammed shut.

The passage from Mars to Earth is relatively easy, if time-consuming. The orbits of Mars ejecta are quickly disturbed by Mars itself into longer elliptical orbits that extend both inward toward Earth and outward into the asteroid belt. Repeated close encounters with Mars, through ~ 10 million years, can nudge the ejecta orbits to cross the Earth's. Then, we get a new martian meteorite!

A Real Live One? The martian meteorites were pretty obscure until this fall, when Dr. D. McKay and co-workers reported the possible presence of possible fossils, organic trace fossils, and mineral trace fossils in one of the martian meteorites, ALH 84001 (*Science* 273, 924-930). Their claims of possible life on Mars are widely accepted, and equally widely disparaged. Expect lots of scientific brouhaha over the next few years!

ALH 84001 is unusual among the martian meteorites — like the other martian meteorites it contains traces of Mars atmosphere, but it alone is very ancient. ALH 84001 crystallized from magma at about 4.5 Ga, and was metamorphosed at about 4.0 Ga (remember that the other martian meteorites are all younger than 1.3 Ga). ALH 84001 was ejected off Mars about 19 m.y. ago (when the Mars atmosphere gas was implanted), and hit the Antarctic ice about 13,000 years ago.

ALH 84001 is a pyroxenite, a cumulate igneous rock, formed by accumulation of crystals from a basaltic magma. One might not expect rock like that to contain fossils of bacteria, but many different kinds of bacteria live inside igneous rocks on earth. In fact, bacteria are being found in almost every imaginable environment, needing little beyond water, carbon, and energy. The energy need not come from familiar sources like light or other organisms — bacteria can get their energy from nearly any chemical reaction (mostly oxidation/reduction couples) that has not come to equilibrium. Some bacteria live very nicely helping rocks rust!

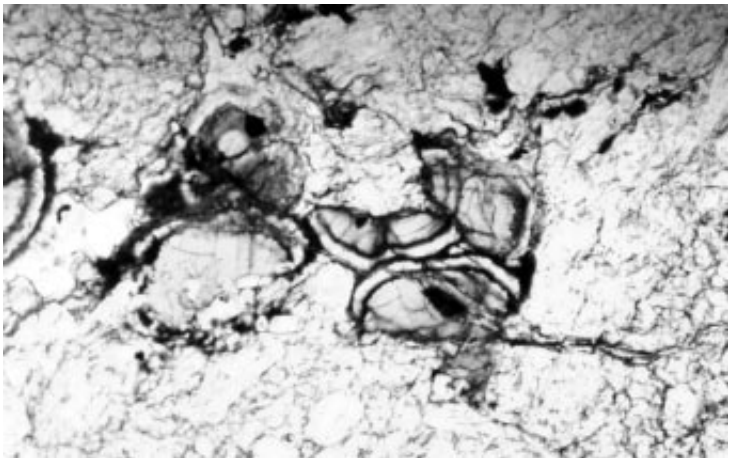

Figure 4. Thin section of martian meteorite ALH 84001 (plane light, 1 mm across) showing half-ellipsoids of carbonate minerals (magnesite-siderite). Dark rings are made of sub-micron magnetite and iron sulfides.

So, before McKay et al. can present credible evidence of possible fossils in ALH 84001, they need to show that the basic ingredients for life were available, including water, carbon, and energy. Evidence for all these preconditions of life are present in ALH 84001, in the form of small ellipsoids of carbonate minerals (Figure 4). The ellipsoids are made mostly of magnesium carbonate, and replace igneous silicate minerals in the rock (principally plagioclase). The ellipsoids did form on Mars — they are older than the shock impact event that lofted ALH 84001 off Mars, and have characteristically martian isotope compositions of oxygen and carbon. The carbonate ellipsoids show all the preconditions for life: 1) they were almost certainly precipitated from liquid water; 2) they are rich in carbon (as carbonate); and 3) their replacement textures are a clear sign of chemical disequilibrium. As the Latin professor would say, QED.

In the carbonate ellipsoids, McKay and co-workers found three different kinds of possible fossils: organic molecules, iron oxide and sulfide grains that could have been produced by organisms, and elongate shapes that resemble 'nanobacteria' on Earth (Figure 5). Taken together, McKay et al. see these three lines of evidence as adequate proof of ancient life on Mars. But many disagree.

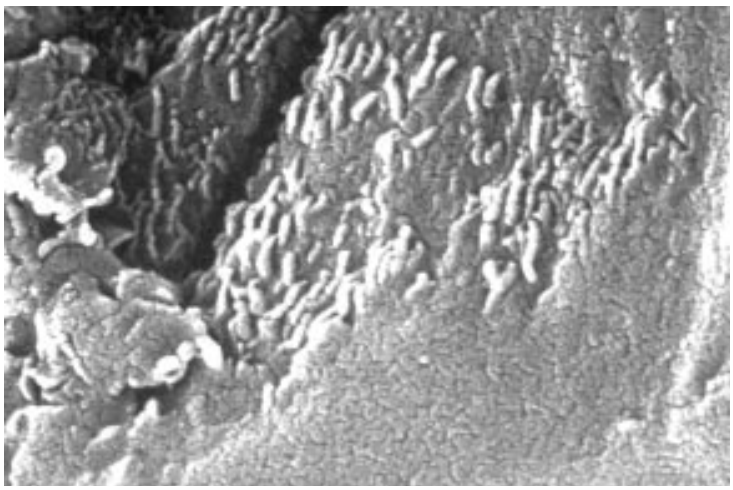

Figure 5. Possible microfossils on a carbonate grain in ALH 84001. Marsbugs from McKay.

First, McKay's collaborators at Stanford university found pico-molar quantities of organic molecules in the carbonate ellipsoids. The molecules they could detect were all 'polycyclic aromatic hydrocarbons,' or PAHs. These molecules are almost certainly martian, and could have been formed by (or from) living organisms, but also could have formed inorganically. Second, McKay's collaborators Thomas and Vali described sub-micron sized crystals of magnetite and an iron sulfide that are similar in size, composition, and structure to crystals formed by some Earth bacteria. Again, the crystals are certainly martian, and could have been formed by living organisms, but similar grains can also form without assistance from life.

Most impressive visually is McKay's third line of evidence — the presence of bacteria-shaped objects on fractures in the carbonate ellipsoids (Figure 5). These sausage-shaped and nearly filamentous objects look very much like bacteria living in rock on Earth, or in the Earth. Their shapes are closely similar to rock-eating ("lithautotrophic") bacteria found in deep subsurface samples of Columbia River basalt. No matter how tantalizing the shapes are, there remains much doubt that they are martian, or even that they are bacteria. First, remember that ALH 84001 landed on Earth 13,000 years ago, and so had a lot of time for bacterial spores to get inside and grow. From this perspective, the shapes in ALH 84001 resemble Earth bacteria because they *are* Earth bacteria. On the other hand, there remains a significant question of whether the bacteria shapes are really bacteria — they could also be mineral deposits or could be artifacts of preparing the meteorite samples for SEM study. For instance, the 'bacteria' in Figure 5 are all aligned on the fracture surface and fairly evenly distributed. Earth bacteria would usually do neither, but would grow in cell clusters and filaments!

So, are they or aren't they fossils? Stay tuned for the next round, coming up at the Lunar and Planetary Science Conference in mid-March. David McKay and collaborators will present more data, including more images of the alleged bacteria, and the skeptics will have their 15 minutes each on the floor. Michigan Geology will be represented — I will be there, and **David Blake** (MS'80, PhD'83) of NASA Ames will likely also. **Der-Chuen Lee** and **Alex Halliday** may be presenting new tungsten isotopic data for SNC meteorites at the same meeting. Come join the fun! (Even Eric Essene is getting planetary; he's been thinking about metamorphism on Venus!)

***Allan Treiman** is Staff Scientist with the Lunar and Planetary Institute in Houston. After his PhD research with Eric Essene he undertook a postdoctoral fellowship with Mike Drake (University of Arizona) producing definitive work on the geochemistry of SNC meteorites and the evolution of Mars. Now recognized as a leading expert he is organizing a major conference on the early evolution of Mars in Houston in April.*

Clarence C. Little

For those of you who wonder who the person was behind the building, here are some biographical snippets about our former University President, courtesy of Mary Jo Frank, University Relations

Clarence C. Little was President from 1925 to 1929. He took the position at the age of 36, having been president of the University of Maine for three years. Holding three degrees from Harvard, including a doctorate in biology, Little came to the University of Michigan with the understanding that he would continue research into the nature and causes of cancer.

Indifferent to the views of persons or organizations outside the University, Little took delight in needling those he didn't like. He lacked patience and tact. For example, he offended Catholics and others when he spoke out boldly and repeatedly in favor of birth control at a time when the subject was seldom mentioned. He once invited members of the House and Senate finance committees to a football game but omitted members he didn't like, thus ensuring powerful University enemies in the Legislature.

Concerned about the welfare of students, Little advocated building dormitories to house 350 to 450 students and two or three faculty members. He inaugurated freshman orientation week in 1927.

Little didn't think the curriculum for men and women should be identical. Reasoning that most women students would become homemakers and mothers, he thought it foolish not to prepare them for those roles. Classes for women that he advocated included physiology, general science, nursing hygiene, human behavior, and heredity and genetics.

In January 1929 Little submitted his resignation. The Regents were unsuccessful in efforts to change his mind. He became director of the Jackson Memorial Laboratory in Bar Harbor, Maine, and served there until retiring in 1956. He also was director of the American Cancer Society.

The above is extracted from an article which first appeared in the November 14th 1996 issue of the University Record and is reproduced by kind permission.

A Bit of History: Alexander Winchell—the Department's longest serving Chairman

by Rob Cox and Henry Pollack

Alexander Winchell was Chairman of the Department of Geology for a total of 31 years in the nineteenth century. As with U.S. President Grover Cleveland's service to the nation, Winchell's service to the Department was divided over two terms, 1855-72, and 1879-91. His career at Michigan actually began two years earlier as Professor of Civil Engineering and Physics, but in 1855 he was transferred to the chair in Geology, Zoology, and Botany. Winchell has been described as an obstinate, unrelenting, driven man, and his penchant for hard work eventually enabled him to become the dominant figure in 19th century Michigan geology. His career included helping to found the Geological Society of America and serving as one of its early presidents, and writing over 250 professional and popular geological works.

From 1855 to 1873 Winchell's career at the University of Michigan blossomed. He oversaw sustained growth in the museum collections, published widely, and developed a national reputation as a lecturer and writer on science. Winchell also managed to find time to organize and direct the State Geological Survey in 1859-61, and again in 1869-73. His classes were popular, if unpredictable, and at times he could be a brilliant speaker. He developed a reputation for getting carried away with a subject and losing track of the hour: students are reported to have slipped out Winchell lectures through doors, windows, or any convenient egress when he began to ramble.

During the first period of chairing the Department, Winchell became involved in a protracted personal dispute with the University president, Henry Tappan. Tappan's strong personality, his inflexible and autocratic style in dealing with the faculty, and the drinking of wine with meals clashed with the inflexible Winchell and other conservative faculty members. Tappan's plans for the university, seen with 140 years of hindsight, would today be called innovative, even farsighted, yet in the 1860s the faculty was badly divided over Tappan's plans, and he faced a growing lack of support among the Board of Regents. Winchell apparently carried on a guerrilla action against Tappan, allegedly acting as an informant to Tappan's enemies on the Board of Regents. In 1863, Tappan was replaced as University president. Winchell, of course, was not a uniformly admired person for his role in the dismissal of Tappan, and in his wider activities in the state he was also frequently involved in disputes. Winchell's resignation from the State Geological Survey in 1871 was said to have been a result of hostility to him.

Winchell left Michigan in 1872 to assume the Chancellorship of Syracuse University, and when that did not work out to his satisfaction, he went on to Vanderbilt University in 1875 to fill the chair in geology. His outspoken support of evolution conflicted with the strongly religious Vanderbilt regents and led to his dismissal after only four years. Winchell returned to Michigan in 1879 to reassume the chair of geology and paleontology, where he remained until his death in 1891. The controversies surrounding Winchell make it hard to present a balanced picture of the man, but his contributions were, by any measure, many. His leadership, even if flawed, provided the basis for both the modern Department and the Museum of Paleontology.

Alumni News

1940's

Helen Foster (BS '41, MS '43, PhD '46) misses her yearly visits to Michigan. She had a great trip to South Georgia, South Orkneys, and Antarctic Peninsula last December and hopes to take a look at Baffin Island and perhaps at least set foot on Greenland in a future trip. Helen (Scooter) sends her best wishes to the Department.

James J. Jamieson (BS '49) lives in Denton TX and is a volunteer local coordinator for AARP's Tax Care for the Elderly (TCE).

Lloyd D. Owens (BS/MS '41) writes from Prescott AZ that he greatly enjoyed the report on the U-M Greenland Expedition, since he can recall Dr. Belknap's stories of his winter on the ice. Lloyd also recalls seeing Dr. Hobbs striding across campus after he had retired with his whiskers blowing in the breeze.

Dorothy Matz Skillings (BS '47) tells us that her son Jerry is married to Abby Spector. He obtained a Doctor of Science degree in Clinical Psychology from Yeshiva University (New York City) in 1987. He is Executive Director of a three-state division of Merritt Behavioral, an HMO-type organization dealing with health coverage for alcoholism and mental health. They live in Bala Cynwyd, a suburb of Philadelphia.

Daughter Carol is married to Tom Stanton. Both are state employees. She has a BS degree in Natural Resources from the U-M (1982) and a BLA degree in Landscape Architecture from Michigan State (1992). She worked about 10 years for the Michigan Geological Survey and is now employed by the Environmental Response Division of the Dept. of Environmental Quality, formerly the Dept. of Natural Resources. They live in Lansing MI. Please note that the Michigan Geological Survey is also now a division of the Dept. of Environmental Quality by gubernatorial fiat not too long ago. The Dept. of Natural Resources was split into two separate departments.

Daughter Laura has both a Bachelors (1993) and a Masters of Education in Career Counseling and Career Development (1996) from Colorado State University, Ft. Collins. She graduated in May and still is seeking employment in her field. She presently lives in Ft. Collins.

Dorothy corresponds regularly with Delores Marsik and Louise Powell and would like to hear from other graduates they knew in 1947. Dorothy lives in Lansing MI.

1950's

John W. Keeler (BS '50, MS '51) retired from Esso Expro UK in 1986. He was employed by various Exxon affiliates for 33 years as a geophysicist in oil Exploration; France 1954-58; Philippines 1966-73; Australia 1968-72; England 1984-86. Prior to Exxon he worked on seismic crews for Texaco 1951-53, and prior to Texaco he was a Geologist with the USGS. Currently he is a general partner with BKD (Bollheimer-Keeler-Depew) being involved in land development in Cameron County and near Arroyo City TX

Walter O. Kupsch (PhD '50), grandpa and now a Member of the Order of Canada, found out that "retirement is a full time job" when in 1995-96, he became a member of a four-person environmental assessment panel on diamond mining in the Northwest Territories; the other persons were the age of his daughters.

William J. Malin (BS '50, MS '52) says he retired in 1993 when they shut down their oil exploration company, Independent Energy Corp. He keeps active in local activities and as an AAPG delegate. He and his wife are thoroughly enjoying retirement, being able to travel whenever they desire and to stay away as long as they wish. Their home is in New Orleans LA.

David A. Rochna (BS '58) is presently Vice President of Exploration for Convest Energy in Houston TX. They are active in onshore and offshore gulf coast, mid-continent and the Rockies.

Lowell R. Satin (MS '55) retired from the World Bank in mid-1994 and, after a few seasons as a VIP (Volunteer in the Park), he is now a "regular seasonal" national park ranger/geologist. During the summer he's at Kenai Fjords National Park in Alaska, and in the winter he is at Hawaii Volcanoes National Park on the Big Island. In both parks Bob is an Interpretive Ranger and leads the daily nature walks (glacial and lava flow and formation) and the weekly "Discovery Walks." Being a "fire and ice" geologist is turning into an exciting "retirement." He would like Geo-alumni to look him up in Alaska and/or Hawaii.

Richard B. Wells (BS '59) sends greetings from the orient. He has been working as a consulting geologist based in Jakarta, Indonesia, for most of the past ten years and would like to hear from any other UM Geo-alumni who might also be there. He thought that 1996 would be an interesting year, and it surpassed his expectations. He's been fortunate to get consulting assignments in Australia, Myanmar, Borneo and Sumatra, as well as a few things in Jakarta. There was a minor gold rush in January which had a major effect on the mineral exploration business. Coal development is also booming, but for now he is back in petroleum exploration. Indonesia is geologically very fascinating, both for the unique tectonic setting and its abundant mineral deposits. The petroleum industry, based in a dozen or so highly productive Tertiary sedimentary basins, employs many geologists from many different countries. There is also quite an interest in micropaleontology.

1960's

Ronald E Seavoy (BA '53, MA '63, PhD '69) was a member of a 42 member delegation on a field trip to the Republic of South Africa sponsored by the Society of Economic Geologists. They departed New York City on November 10, 1995, and returned on November 27. The following mineral localities were visited with appropriate inspections of mines and quarries: Witswatersrand gold bearing conglomerates; Palabora, copper in a carbonatite; Murchurson greenstone belt antimony mine; Finsch kimberlite pipe; Samancor manganese quarry; Black Mountain lead-zinc; O'Kiep copper; alluvial diamonds at mouth of Orange River, Namibia. Currently, Prof. Seavoy is continuing visiting professor in the Department of Business Economics and Public Policy, School of Business, Indiana University, Bloomington. He has been teacher there for the past four years after retiring from teaching U.S. Constitutional History at Bowling Green State University, Bowling Green, Ohio.

Charles I. Smith (PhD '66) has retired from the Department of Geology at the University of Texas at Arlington and is now living in Ruidoso NM.

1970's

Steven A. Catlin (BS '78) writes that he is still working in environmental geology (close to six years now) and has received his hydrogeologist certification (CHG).

Roger L. Gilbertson (PhD '72) has celebrated his 20th anniversary with BHP Petroleum. After two years in Houston TX (following five years in Buenos Aires, Argentina), he has accepted an opportunity to transfer to Santa Cruz, Bolivia, with BHP.

1980's

Teresa S. Czarnik (BS '84) writes that in the fall of 1995 she and her husband vacationed in southwestern Washington (including Mt. St. Helens) and western Oregon (including Columbia River Gorge and Oregon dunes). The hexagonal jointing of the basalt near Multnomah Falls in the gorge was textbook material. Teresa is currently working as a volunteer for the scientific assistant to the curator of mineral deposits at the American Museum of Natural History, Department of Earth and Planetary Sciences.

Jim Evans (BS '81) continues as associate professor at Utah State Univ.. Their last field camp had 32 students and visited Camp Davis for eleven days, working on the Darby Thrust project at Astoria and Fall Creeks, and using total stations to evaluate debris flows in T6 Hobak Is Canyon.

Neil F. Hurley (PhD '86) is a Prof. at Colorado School of Mines and the Charles Boettcher Distinguished Chair in Petroleum Geology. In 1997 he will take over as the elected editor of AAPG. Neil's responsibilities will be to oversee technical (scientific) aspects of *AAPG Bulletin* and AAPG books.

Susanne Janecke (BS '81) was awarded tenure and promoted to associate professor at Utah State University. She continues to work on evolution of extensional basins, early tertiary basins of Montana and Idaho, and folding in extension. She also wildly enjoys their 2.5 year old daughter Erica.

Margaret E. Mooney (BS '83) has been working for the National Weather Service since 1985 in Madison WI (the Ann Arbor of WI). She and her partner Meg have two children, Reed and Grace. Although her work has taken her from the lithosphere to the atmosphere, she takes great pride in having the best rock garden on the block.

Scott W. Tinker (MS '85) has done a 3-D characterization of carbonate reservoirs for Marathon Oil Company. He received his PhD on reservoir-scale sequence stratigraphy from the University of Colorado this year. Scott and his family live in Englewood CO.

1990's

Lisa Churchill Dickson (MS '94) spoke at the North American Paleontological Conference in Washington, D.C., this June and presented findings from her master's thesis: Testing for differences in selectivity during mass and background extinctions using the fossil record of Trilobita. Lisa was married in July to Stephen Dickson. They spent their honeymoon in Paris and stopped by the Paris natural history museum. Talk about a little shop of horrors! Lisa and her husband live in Augusta ME.

What the media say...

We are starting a new column of snippets from the media relating to the Department and its alums. To start the ball rolling here is an extract from the New York Times regarding the recent work by Lynn Walter's research group on the Antrim Shale...

"...Beyond minerals, scientists are studying realms like microbial influence in the formation of gases. An example of such work appears in the Sept. 12 issue of the journal *Nature.*

Scientists from the University of Michigan at Ann Arbor and the Chevron Petroleum Technology Company in La Habra, Calif., studied a big natural gas field in Michigan that was thought to have been made as the earth's heat cooked rich organic remains in a bed of shale about 370 million years old. Shale is a fine-grained rock made of ancient silt and clay.

But it turned out that the gas was actively produced by billions of microbes, as revealed in part by high concentrations in industrial gas wells of carbon-13, a kind of microbial excreta and a sign of active life. Carbon at the earth's surface occurs in a variety of isotopes, or forms, including carbon-13 and carbon-12, which most plants and animals prefer.

The finding is "economically important and unexpected," said Anna M. Martini, an author of the *Nature* paper at the University of Michigan, adding that it pointed to new sources of natural gas globally."

The above is quoted from an article by Bill Broad which appeared in the October 15th 1996 issue of the New York Times.

GS 265:

Where the Internet Meets the Big Bang

by
Susan Topol of The University of Michigan's Information Technology Division

Students in Professor Ben van der Pluijm's winter term Geological Sciences 265 class didn't just learn about the Big Bang and the Earth, they learned about the latest Internet technology as well.

GS 265, "How to Build a Habitable Planet," is designed to help non-science majors explore scientific subjects. The course description reveals that it offers an interesting overview of the world of geological science. "Formation of the universe, sun, and Earth, and societal interactions with our planet form the basis of this course that is primarily aimed at first-year students who wish to explore a scientific perspective to our physical world and examine humankind's role. Topics including the Big Bang, formation of stars and planets, the Earth's age and its structure, continents and oceans, ice ages, resources, and human impact will be discussed."

What the description doesn't reveal is van der Pluijm's innovative approach to the material.

Innovative Approach

"One of my goals was to make the students enjoy science and to interpret it using their own perspectives," explained van der Pluijm. One of the innovations he introduced was to make the Internet an important focus of the class for both performing research and for producing the final class assignment—a World Wide Web page.

Web pages can include text, full-color graphics, animation, video, sounds, links to other resources, and more. Because of the richness and exciting potential of this medium, van der Pluijm decided to have students create a Web page as their final project instead of a traditional term paper.

"The Internet focus of the class helped students to use their creativity and give their own personal interpretation to the material," stressed van der Pluijm. "The Web pages allowed students to use images to make the text more alive and helped them learn how to write for a wider audience."

New Tools

Van der Pluijm wanted his students to gain experience using some new technologies, including Windows 95 and a pre-release copy of Netscape Navigator Gold 2.0. Although the majority of courses on campus use the Macintosh, van der Pluijm chose to use Windows instead. Why?

"I felt strongly that students should have more experience using Windows, because they are likely to encounter it in the workplace after graduating," explained van der Pluijm. "I also wanted to use the newest technology, and Windows 95 was new."

Different Skill Levels

The students brought differing computing skill levels to GS 265. While many had no prior experience with the Internet beyond e-mail, others were already comfortable in cyberspace. To bring everyone up to speed, GS 265 class lectures included instruction in using Netscape and other Internet tools.

Van der Pluijm found that using an integrated package, such as Netscape Navigator Gold, made it easier for students to learns. "Navigator Gold provides kind of a one-stop-shopping approach to creating home pages," said van der Pluijm. "Everything the students needed for creating, viewing, and posting their Web pages was there in one package."

A Windows 95 workstation, funded by the Geology Department, and additional equipment (including a scanner and a printer) were available for students to use. Each Friday, students would gather around the workstation for impromptu technology tutorials. Students used this opportunity to become more familiar with the hardware, the software, and various aspects of Web page design, as well as to explore Web resources.

GS 265 students were happy about using the Web. Student Amit Kalaria said, "It was exciting to find out we would be incorporating the World Wide Web into our class. It was really beneficial because we learned how to use the Web to search for information while at the same time make our own home page."

Student Daniel Goldstein agreed, "It gave me a chance to learn more about the Internet, so I looked at the course with enthusiasm."

Doing Research

Students also learned how to use the Internet as a research tool. Although the course used a textbook and followed a regular lecture format, students were not allowed to include either the textbook or lecture notes in the content of their home pages. Instead, students used Internet searching tools to find information resouces.

To ensure that content and technology were balanced in the final projects, van der Pluijm had all the students submit a proposal containing just the text of their project at midterm. Once their proposals received approval, the students proceeded to create their Web pages.

A Team Effort

Working in pairs, the students not only created their own pages, but had the opportunity to read, comment on, and grade the other teams' work as well. By evaluating each other's work students were able to learn far more material than they would have if they only focused on their own projects.

"It was helpful to work with a partner because it combined the importance of teamwork with learning," said Kalaria. "Also, since two heads are better than one, partners made it easier to overcome difficulties in designing a Web page."

What did the students think about using the Web in comparison to more traditional classroom methods? "A million times better!" said student Tina Chow. "You get a true sense of accomplishment. It is really rewarding when you can show your fellow classmates your work as well as showing off to your parents at home what you have worked on at school."

Added Kalaria, "It really is a lot better because it incorporates writing a paper and looking up materials with making a Web page. Plus, it allows others to see our findings."

"I found the usage of the Web to be the most interesting aspect of the class," said Goldstein. "It provided a suitable alternative to conventional research without lowering its quality."

Workplace Skills

Van der Pluijm also hoped that the Internet skills learned in his class might aid students in their future endeavors. This certainly proved to be true for GS 265 student Art Holland.

Said Holland, "At my current summer job I have been given the assignment of creating a company Web site, since I am the only one at the establishment with any experience with creating, editing, or using Web sites."

Chow also concurred: "Having such publishing skills is definitely an asset that you can use to your advantage in the workplace. Today, companies are looking for people who are computer literate, and having Internet knowledge is definitely a double plus. It helped me in landing an awesome internship at an investment firm."

Two Courses in One

Van der Pluijm admitted that the class was intensive from a teaching perspective and credits the Center for Research on Learning and Teaching for providing a faculty grant that allowed him to put in the extra time required to develop the class. Van der Pluijm concluded, "It was a lot of work, almost like teaching a software class and a science class at the same time."

That extra work paid off, though. "Students were enthusiastic, well-engaged, and attendance was at 90% for the class," said van der Pluijm with satisfaction.

The above article first appeared in the September 1996 issue of the Information Technology Digest and is reproduced by kind permission.

Robert A. Berner wins the 1996 Day Medal

Bob Berner (BS '57, MS '58) is this year's recipient of the Day Medal. Bob and his wife Betty (BS'58 - then **Elizabeth M. Kay**), shown together in this recent photo, are alumni of our department and have just published a book together, "Global Environment: Water, Air and Geochemical Cycles" (Prentice-Hall, 1996). The Arthur L. Day Medal is awarded by the Geological Society of America for outstanding distinction in contributing to geologic knowledge through the application of physics and chemistry to the solution of geologic problems. It serves to recognize outstanding achievement and to inspire further effort, rather than to reward a distinguished career. The citationist at the recent awards ceremony in Denver was John Morse (Texas A&M) and much of what follows is extracted from his citation with kind permission.

"The field of low-temperature geochemistry has evolved dramatically during the second half of the twentieth century, and much of this evolution is directly attributable to the vision and leadership provided by Bob Berner. Through his many innovative papers, scholarly books, and dedication to teaching, he has had a major intellectual impact on a whole generation of geoscientists. His outstanding research has contributed substantially to the field of low-temperature geochemical processes blossoming into a wide range of subdisciplines that include chemical oceanography, sedimentary geochemistry, environmental geochemistry, biogeochemistry, and the geochemistry of global cycles.

During much of his career, Bob's attention has focused primarily on processes associated with the early diagenesis of sediments. This research has revealed the complexity of interrelationships among physical, chemical, and biological processes occurring near the sediment-water interface and has resulted in his development of complex mathematical models for diagenesis to describe and quantify these processes. One of the most important impacts of these studies has been to lead the field of "low-temperature" geochemistry away from a strong reliance on equilibrium thermodynamics and into the application of kinetic theory to the dynamic geochemistry in near-Earth surface environments. In recent years Bob has largely focused his efforts on modeling the global carbon cycle over Phanerozoic time, and how atmospheric CO_2 and O_2 have varied in response to geologic processes and the evolution of organisms.

It is for these many accomplishments, along with the inspiration, guidance, and friendship that he has provided to so many, that Robert A. Berner has been honored with the 1996 Day Medal.

David Fountain Receives GSA Distinguished Service Award

David Fountain (BS '69, MS '71) is the recipient of the 1996 GSA Distinguished Service Award for his contributions during six years as co-editor of *Geology*. During this period he has shepherded many hundreds of papers through the receipt, review, revision, and acceptance (or rejection) process. Seeing the need for a tailored tracking system for manuscripts and the people—authors, reviewers, and editors—associated with them, he developed such a system, now very close to being networked among the editors and headquarters. Ranging more widely, he initiated meetings of journal editors to share their concerns and address such issues as duplicate publication. These gatherings, held at GSA annual meetings, have led to increased communication among journal editors. This award does indeed recognize the distinguished service of David Fountain.

John H. DeYoung, Jr. given Herbert C. Hoover Award by SME

John H. DeYoung, Jr. (MS '69) received the 1996 Herbert C. Hoover Award from the Washington D.C. Section of the Society for Mining Metallurgy and Exploration (SME). He received a B.S.E. degree with honors in civil and geological engineering from Princeton University (1967), an M.S. in economic geology from the University of Michigan (1969), and Ph.D. in mineral economics from The Pennsylvania State University (1975). He was a Distinguished Military Graduate from Princeton University Army ROTC and served on active duty as a field artillery officer at Fort Sill, Oklahoma, and Nha Trang, Vietnam. While in Vietnam, he was awarded the Bronze Star Medal. To add to the accolades, this year John was designated as one of 240 Centenial Fellows to celebrate the 100th Anniversary of the College of Earth and Mineral Sciences at the Pennsylvania State University. John is a mineral economist in the Mineral Resource Surveys Program of the U.S. Geological Survey (USGS). He is Chief Scientist of the Minerals Information Team at USGS. His research in the mineral-resource programs of the USGS (1975-85, 1993-95) has included regional mineral-resource assessment in Alaska and the eastern United States, the effects of tax laws on mineral exploration in Canada and the United States, the cumulative tonnage-grade distribution of mineral resources, capital formation in the mineral industries, the effect that physical attributes of mineral resources have on metal supply, and a National assessment of undiscovered metal resources. Some of his other assignments have been serving as Deputy Chief and Associate Chief of the former Office of Mineral Resources (1985-93), representing the USGS Director on the

Secretary of the Interior's Advisory Committee on Mining and Mineral Resources Research (1986-94), and serving on the staff of the Policy Coordinating Committee for the Presidential Review of Nonfuel Minerals Policy (1978-79). He is Executive Secretary of the International Studies of Mineral Issues working group, a cooperative project of the USGS and seven other mineral-resource agencies from five other countries. In 1995, he received the U.S. Department of the Interior's Meritorious Service Award.

Congratulations John!

Rob Van der Voo as Recipient of the Alumni Outstanding Faculty Award

The Geology Alumni Board Outstanding Faculty Award is given on an occasional basis to faculty of particular accomplishment. This year the award went to **Rob Van der Voo**.

Rob received his doctorate from Utrecht in 1969 and so has been doing geology and geophysics for three decades. In that time he has achieved remarkable stature among his peers by dint of: focusing on truly significant problems in the earth sciences; refining his approach and that of his entire field of paleomagnetism and rock magnetism to those problems; publishing profusely — 60 or more articles in this decade alone, along with a widely respected book; and mentoring students now ensconced in laboratories around the world.

Not being satisfied with scholarly achievement along, Rob has also contributed much to his profession in both service and administrative roles. He has served as editor for *Earth and Planetary Science Letters* and associate editor for *Geophysical Research Letters*, *Tectonophysics*, *Journal of Geodynamics*, and *Tectonics*. In addition to editorships, Rob has worn several hats at the American Geophysical Union, including member and chair of several committees and President of his Geomagnetism and Paleomagnetism Section.

Over the past five years Rob has made contributions to our undergraduate education program at Michigan that are particularly significant. He was one of the leaders in the development of undergraduate seminars, a new and highly successful classroom format within which freshmen in particular are taught in small groups, permitting close interactions with faculty members. We at Michigan particularly honor his service to us and the University as Chair of the Department of Geological Sciences. Rob served as chair for a total of 11 years, from 1981-1988 and again from 1991-1995. This makes him the longest serving chair in the modern era of the Department. During his tenure he was a primary architect of the Bold Initiative of 1985 that outlined the department's path to greatly enhanced stature and was in the chair's office during most of the time it was carried out. The results of that decade long effort by the department are evident in the Report of the External Review Committee and in the two different national rankings that have come out in the past year.

Rob is not without recognition for his many efforts. He became a Correspondent (foreign member) of the Royal Academy of Sciences of the Netherlands in 1979, a fellow of the American Geophysical Union in 1982, received the G.P. Woollard Medal of the Geological Society of America in 1992 and was inducted into the Norwegian Academy of Sciences and Letters last year. The University has also recognized Rob's contributions by awarding him the Henry Russel Award in 1976, the U of M Distinguished Faculty Achievement Award in 1990, LS&A Excellence in Education Awards in 1991 and 1992, and the Arthur F. Thurnau Professorship which he occupies from 1994 to 1996.

To commemorate this career of accomplishment, from which everyone associated with our department since 1970 has benefited, we are delighted to award Rob with the Outstanding Faculty Award.

Class of '86 Camp Davis Reunion: We Were Geologists Once . . . and Young

by Kevin Mackey

This past summer marked the 10-year reunion for the 1986 Geology 440 class. In 1986, the fifteen students in attendance dubbed the class "HELL CAMP." HELL CAMP consisted of hell hikes, jake staffing from hell, the Atlantic city hell project, and warm hell beers. Hell camp included the customary camp T-shirt whose art work was a steep mountain of empty beer cans with a metal cabin on top and a figure jake staffing up the side. A side effect of hell camp was the creation of close friendships and exposure to the unparalleled splendor of the West. At the end of that summer, all promised that in ten years we would again meet at Camp Davis.

Flash forward a decade. With the help of **Bob Owen**, **Carola Stearns**, and **Chuck Wooden**, promises were kept. With their

help, current addresses were obtained, a date was scheduled, and lodging arranged. All former 440 students and staff were invited to attend, and the mid-August 1996 HELL CAMP REUNION was on.

Six students and two staff members were able to attend. The students were **Jim Ferritto**, **Anne Fitzpatrick**, **Dave Macabe**, **Kevin Mackey**, **Karen Warren**, **Dan Wiitala**; and yes, hell camp survivors have significant others and offspring, too. **Eric Essene** and his wife **Joyce Budai** joined the group as representative hell staff. Together, everyone enjoyed Camp Davis hospitality provided by **Chuck Wooden**. Although the years have seen many changes in the lives of the Hell campers, they still managed to "put the hammer down" in true Hoback style (at least for a night or two).

The schedule was kept open to allow everyone a chance to do whatever they wanted. Some chose to fish for native cutthroat in the rivers around camp. Others visited the hotsprings or went into Jackson. The only requirement was that everyone met back at camp for beers around the fire pit. The conversations around the fire included rehashing old memories, our best imitations of K.C. and Ben on the radios, discussing the state of geology in general, and getting caught up after ten years. The friendships, born ten years ago and strengthened by the experiences of field camp, still exist.

The end of the reunion came too quickly. Just when we had gotten our beer legs back it was time to leave Camp Davis. Instead of piling into the vans and driving off into the sunset, we loaded up the family trucksters, buckled the kids in their seats and promised to do it all over again. The next reunion will be in the year 2001. It will be named the 2001 HELL ODYSSEY REUNION.

The latest news from Camp Davis

Given the importance placed on fieldwork in our undergraduate curriculum, and the fond memories conjured up for so many of our readers, we have decided to start a regular feature on Camp Davis.

This year, GS116 consisted of some 35 students who studied regional geology in and around Wyoming. They were guided by Professors **Skip Simmons** (shown above lecturing at Obsidian Cliffs in Yellowstone), **Bob Owen**, **Karen Webber**, **Carl Drummond**, and were joined for a few weeks by traveling professor **Peter van Keken**. The TA's responsible for day-to-day operations were **Henry Fricke**, **Holly Godsey**, and **John Harris**. Highlights of the summer included two regional trips, which took the students and staff through Wyoming, Montana, Idaho, Nevada, and Utah. High up in the Rockies, inclement weather forced some use of rain gear (as shown here with the group of students in front of deformed Chugwater sandstone). Although the annual snow festival was avoided by camping at the foot of the Beartooth, some tents were lost in the appropriately named Wind River Canyon. The more desert-oriented trip through Idaho, Nevada and Utah exposed many of the students to the "real" wilderness for the first time. Water on the Bonneville salt flats made racing impossible, but one of the TA's was nevertheless able to continue his demolition derby — this time by blowing the transmission of one of the vans on the way back to camp.

More photos are available on the Web at

http://www.geo.lsa.umich.edu/~keken/116.html

http://www-personal.umich.edu/jhharris/cdavis.html

The 1996 GS440 class consisted of 20 students (a small but dynamic group!) studying advanced field geology in the Rocky Mountains. The class kicked off in late June in Colorado Springs, Colorado. The eight-day field trip was led by Dr. **John Geissman** with TAs **Will Clyde** and **Meg Streepey**. The trip took 440 students through Colorado, New Mexico, and Utah, finally arriving at Camp Davis in early July. Dr. **Kacey Lohmann** took over for the next few weeks and guided the students through the introductory part of the course. Highlights included a cold and somewhat dangerous rafting trip down the Snake River (together with the GS116 students) and a spectacular four-day field trip through the Bighorn Mountains, the Beartooth Mountains in Montana, and Yellowstone National Park. After the trip, the students were put to the test by Professors **Rob Van der Voo** and **Becky Lange** in a mapping project in Atlantic City, Wyoming, and finished off the course in scenic Alta, Utah, with a final mapping project. 440 students have managed to stay in contact via a much-used email group and often reminisce about the summer's events.

We thank Peter van Keken and John Harris for keeping us informed.

Focus on Research in the GIGL

The Geochronology and Isotope Geochemistry Laboratory (GIGL for short) was constructed several years ago when **Sam Mukasa** joined the faculty after four years as an assistant professor at the University of Florida. The ultra-clean chemistry laboratories, designed for high-precision, low-blank, multi-element chemical separations, are subdivided for different tasks allowing Sm-Nd, Rb-Sr and U-Th-Pb isotopic analyses on very small samples. Each of the rooms in the lab is supplied with clean air which has been passed through HEPA filters to remove particulate matter and through charcoal traps to remove aerosol-carried ambient Pb. The lab is also well equipped for mineral separations, particularly for zircons - the favorite with U-Pb geochronologists. Covering some 960 square feet, the laboratory is big enough to accommodate simultaneously the research activities of several students and post-doctoral research fellows, as well as in-house and visiting faculty colleagues. Once chemical separations have been completed, the samples are analyzed with mass spectrometers housed in the Radiogenic Isotope Geochemistry Laboratory (RIGL).

Since coming to Michigan, Sam has focused his attention on sorting out problems in global tectonics, mantle geochemistry, and magma chamber processes. "To do all this I need a good team" says Sam. The primary giglers are as follows. **Sandy Zeff** (BS '91) manages the GIGL and is also in charge of training new students and visitors in the art of low blank chemical separations. Helpers in the last few years have included **Linda Koch** (BA '89), **Amy Koh** (BS '93), **Eric Tishkoff** (BA '91), and **Dino Van Denheede** (BS '94). Graduate students have included **John Encarnación** (PhD '94), recently a postdoctoral research fellow at Ohio State University but now an assistant professor at St. Louis University, **Jean Tangeman** (MS '93), now a PhD student with **Becky Lange**, and current students **David Minor** and **Pinbo Zhou**. Also, visitors from Arizona State University, Cambridge University, and the University of Florida have used the facilities. "We are expecting some new faces from the University of Natal, South Africa, and an oceanographic institute in St. Petersburg, Russia, in the new year" comments Sam.

1(a) Map of Antarctica showing the times during which the various southern continents broke away. (b) A reconstruction of the original positions of the various fragments that composed the Gondwana supercontinent.

A range of global tectonics projects have been underway in locations as far afield as Antarctica, Ghana, Philippines, South America, and Zimbabwe. The mantle geochemistry projects in Sam's group have involved samples from California, Thailand, the French Pyrenees and the Italian Alps. Recently Sam has been increasingly interested in magma chambers, in particular the large, water-poor layered mafic intrusions in Antarctica and Zimbabwe. "I enjoy evaluating the analytical data we obtain from the lab, but I also enjoy immensely the fieldwork that comes first" says Sam. He is clearly doing this on a global scale. Sam recently talked to us about some topical examples from the three main research areas.

Continent breakup around Antarctica

East Antarctica was the nucleus of the supercontinent Gondwanaland from which Africa, Australia, India, and South America separated during the Jurassic and Cretaceous (Figure 1). Smaller West Antarctic crustal blocks, largely the product of Paleozoic and Mesozoic tectonic and magmatic accretion on to the proto-Pacific margin of Gondwanaland are no less important inasmuch as their jostling, as recorded by igneous and metamorphic rocks in each of the blocks, tells us a great deal about the assembly of supercontinents. The eventual separation of Greater New Zealand (Campbell Plateau, Chatham Rise, and North and South Island, New Zealand) from the rest of the West Antarctic microcontinents led to the birth of the modern South Pacific Ocean, and indeed to the establishment of the modern global atmospheric and oceanic circulation patterns. It also ensured that Antarctica would become surrounded by mid-ocean ridge systems on all sides, maintaining a polar position where it has become a very effective climate modulator.

The tectonic evolution of Marie Byrd Land, the largest of the West Antarctic microcontinents, has been a particular focus of work in GIGL over the last few years and has involved three expeditions to the field and a substantial amount of lab work. Zircon U-Pb ages for metaluminous granodiorites, monzogranites and granites from western Marie Byrd Land reveal a remarkably

protracted period of subduction-related calc-alkaline magmatism lasting between at least 320 and 110 myrs. $^{40}Ar/^{39}Ar$ ages for a variety of minerals in rift-related layered gabbros are all around 100 myrs are believed to be indicative of very rapid cooling and advanced crustal thinning. In eastern Marie Byrd Land, the calc-alkaline magmatism was not terminated until 96 myrs, which suggests subduction shut off from west to east as the result of ridge subduction, analogous to zipper closure.

"With zircon U-Pb ages clustering around 100 Ma, "anorogenic" syenites and quartz syenites in western Marie Byrd Land show that the transition to extension-related magmatism was fairly rapid" comments Sam. "However, complete separation of Greater New Zealand from Marie Byrd Land did not occur until 84 Ma when oceanic crust corresponding to chron 34 appeared between the two land masses. Thus, we now know that the time taken from the first signs of rifting to complete separation was about 24 million years."

Basaltic volcanism of S.E. Asia

Basaltic magmas usually originate from the asthenospheric mantle, but the interaction between such melts and the highly heterogeneous continental lithosphere is considered to be a possible cause of their compositional diversity. The extent of this interaction is still hotly debated. Working with graduate student **Pinbo Zhou**, Mukasa has examined basaltic rocks in Thailand that have been extruded through lithospheric blocks of different thicknesses to gauge the importance of the interaction to the eventual compositions of the basaltic magmas.

"Our work has found that in spite of differences in the thickness of the lithosphere through which they ascended, Thai Cenozoic lavas fall into only two distinct groups" says Sam. Pinbo and Sam have now shown that, paradoxically, group I has a moderately depleted isotopic signature, but enriched and variable incompatible trace element compositions, whereas Group II despite having an enriched isotopic character, has less enriched and less varied trace element compositions. "It is as if the magmas and their source regions have been totally switched!" laughs Sam. "We believe variations in the concentration of major and trace elements in group I magmas result mainly from different degrees of partial melting of mantle source materials at different depths." This conclusion is based on the fact that the highly incompatible trace elements are most enriched in silica-poor and alkali-rich basalts, namely basanites and alkali-basalts, which are widely held to result from small degrees (2-10%) of partial melting of incompatible-trace-element-enriched mantle sources at high pressures (>15 kilobars). The inverse correlation between the highly incompatible trace elements and silica, inexplicable in terms of fractional crystallization, makes sense with this model. In the generation of basaltic magmas from a peridotite mantle, the silica content in melts is pressure dependent, increasing with decreasing pressure. With extensive decompression the degrees of partial melting of mantle materials will also increase. Therefore, smaller degree of partial melting of deep mantle materials accounts for the enrichment of alkalis and incompatible trace elements and deficiency in silica; conversely, larger degree of partial melting of shallower mantle materials is responsible for the higher silica and the lower concentration of alkalis and incompatible elements.

Group I lavas share their chemical and isotopic characteristics with Cenozoic basaltic rocks from southeast China and post-spreading seamount lavas erupted through oceanic lithosphere in the South China Sea. This suggests commonality in the principal magma source for these three volcanic provinces, and supports the notion of the major mantle source being in the asthenosphere. In contrast the enriched isotopic compositions recorded by the group II rocks are believed to result mainly from contamination of the asthenospheric magmas by lithospheric materials.

Tent city for the recent US-UK-New Zealand expedition to Marie Byrd Land, West Antarctica.

Field party loading ski-equipped aircraft with rocks at the Dufek intrusion, Antarctica.

The spectacular cumulate layering in the Dufek intrusion which fooled the first visitors into thinking that these were sedimentary rocks.

The giant Dufek layered intrusion, Antarctica

Layered mafic intrusions emplaced near the margins of continental blocks are important to understanding plate fragmentation processes, and are an excellent source of information about the tectonic history of supercontinents and mafic magma crystallization in natural systems. These plutonic complexes typically occur in mobile belts and rifts, and often contain datable materials that yield crystallization ages. This geochronologic information serves to constrain the timing and

duration of associated rifting events because early mafic magmatism commonly predates full-fledged fragmentation and is often of relatively short duration. Rift-related lava flows and plutons are also more likely to be preserved than the seafloor record for any continent fragmentation event. In addition to chronological information, layered mafic intrusions may also be part of large igneous provinces that can provide geochemical information about the type, location and geochemical history of the mantle source region. All of these data can then be integrated for evaluating rift mechanisms.

With a team consisting of graduate students **David Minor** and **Pinbo Zhou**, and three professional mountaineers from New Zealand, Mukasa has spent two field seasons studying the Dufek intrusion, a large layered mafic body in the Pensacola Mountains, just south of the Weddell Sea. Nearly as big as the more famous Bushveld Complex in South Africa, the Dufek intrusion is believed to have been emplaced into a Jurassic failed rift-arm, and is spatially associated with volcanic rocks of the Ferrar Magmatic Province, a large igneous province generated during fragmentation of the Gondwana supercontinent (Figure 1). It is mainly gabbroic, but also contains significantly large layers of pyroxenite, anorthosite and leucogabbro that are enigmatic in assessments of liquid lines of descent. The layered gabbros are capped by several hundred meters of granophyre, a highly silicic medium-grained rock that in other intrusions has fueled the debate between those who view it as a product of extreme crystal fractionation and proponents of massive crustal assimilation or even liquid immiscibility. Sam and his team consider that they have already nailed that problem. By using neodymium, strontium and lead isotopic measurements the granophyre has now been shown to be the product of mixing between magmas similar to the upper gabbros in the intrusion and the local crustal materials. "The proportions are about 90 percent gabbroic magma to 10 percent pre-existing crustal materials" comments Sam.

Recently Sam's group has put together very precise U-Pb age constraints on the longevity of this massive basaltic system. A new age of 183.9 ± 0.3 myrs (2σ) for the initiation of magmatism defines the approximate time at which Africa and Antarctica began to separate, whereas a cross-cutting silicic dike has produced a U-Pb zircon age of 182.7 ± 0.4 myrs (2σ), providing a minimum age for the entire gabbroic sequence. These data show that magmatism in the giant Dufek intrusion lasted a couple of million years at the absolute maximum. These new Dufek age data are in excellent agreement with recent zircon and baddeleyite U-Pb age determinations by former student **John Encarnación** of 183.6 ± 1.0 myrs and 183.7 ± 0.6 myrs for basaltic sills from the Ferrar (Antarctica) and Karoo (South Africa) continental flood basalt provinces. Sam says "A general picture is beginning to emerge from these studies that Ferrar Group magmas were erupted over a very short interval of time, coinciding with at least some of the magmatic activity in the Karoo province of southern Africa. If additional dating programs confirm that Ferrar/Karoo eruptions occurred over a very short time span (<2 myrs), this belt will be recognized as one of the most extensive continental flood basalt outpourings in Earth's history."

Geological Sciences on the World Wide Web

by Larry Ruff

Our department has joined the stampede to stake out some territory on the world wide web. From our initial experiments early last year, our department web pages have now grown to number about one hundred. More important than the number of pages, you can find information on diverse topics such as: faculty research interests, class information, e-mail addresses for all department personnel, course schedules, Turner Lecture schedules, graduate student application materials, research facilities, Camp Davis, the departmental brochure, and even this newsletter! Furthermore, individual faculty, students, and research groups have added hundreds of more specialized web pages that present research results, specialized catalogs, and lecture materials. In particular, our departmental web is host to the primary web pages of the International Heat Flow Commission. For a more local flavor, we also host the primary web pages for "MichSeis," the program to promote and operate digital seismographs throughout Michigan. All of this information is linked together, and of course there are numerous outside links into various specialized parts of this web structure. Usage of our web pages has increased in dramatic fashion over the past year and a half — this fall term we are now averaging about 1,000 "hits" per day! Many people have contributed to this effort. **Dale Austin** is our department "webmaster," and he is busy added new resources to the departmental pages. **Mike McNally** is our Unix Systems expert, and he keeps the web server up and running. Thanks should be extended to **Shaopeng Huang**, **Nazli Nomanbhoy**, **and Yuichiro Tanioka** for their help with some technical aspects, and Prof. **Ben Van Der Pluijm** was instrumental in establishing our current department-wide scope and format. We must give special thanks to all the enthusiastic individuals who have spent many hours adding interesting resources and information to our web structure.

Please spend some time clicking about our department! Home page URL is:

http://www.geo.lsa.umich.edu/

Note "lsa" is lower case "LSA".

Faculty, Research Staff, and Student News

Jeff Alt returned in September from six months as a visiting professor at Université Louis Pasteur in Strasbourg, France, where he had the opportunity to catch up on writing papers and do some traveling, as well as familiarize himself with the Alsatian lifestyle. Despite his last experience at sea (see article in the previous newsletter), as of the writing of the present newsletter **Damon Teagle** is at sea finishing up the final weeks of Ocean Drilling Program Leg 169 in the NE Pacific (drilling into active and fossil submarine massive sulfide deposits).

Robyn Burnham continued investigations in high diversity tropical forests in eastern Ecuador. While there, she studied accumulations of forest leaf litter deposited on the point bars of the Rio Tiputini. The deposits appear to accumulate during times of stability of the river channel. In addition, she has been investigating the importance of climbing plants in fossil and modern tropical forests.

This summer, **Eric Essene** and **Ben van der Pluijm** visited **Meg Streepey** in her current field area along the Carthage-Colton mylonite zone in the NW Adirondacks. This is an area familiar to Eric from research with **Steve Bohlen** (PhD '79), **Phil Brown** (PhD '80), **Larry Edwards** (MS '86), **Karen Hoffman** (MS '82), **Craig Johnson** (MS '81), **Klaus Mezger** (Postdoc '90), **Erich Petersen** (PhD '84), **John Valley** (PhD '80), and **Alex van den Berg** (MS '78) in the Adirondacks. Scanlan's Store in Harrisville is still producing the same excellent doughnuts, especially since it was bolstered by daily visits of Klaus, Ben and other U-M aficionados while in the field. By the way, Klaus is soon moving from the Max Planck Institute to take a prestigious professorship at the University of Muenster in Germany.

In August, Eric, Joyce and their family visited Camp Davis and attended the 440 student reunion (class of '86). Eric also spent five days in the Wind River Mountains of Wyoming with **Steve Keane** looking at Archean metamorphic rocks in the southern portion of the Paradise Basin Quad. This work represents in part a continuation of research begun by **Zach Sharp** (PhD '88) and **Charlie DeWolf** (PhD '93) elsewhere in the Winds. Once again, the trout fishing was great — and so were the rocks! Eric attended the Denver GSA meeting this fall to deliver a paper on the use of trace levels of Zr in garnet as a barometer with Steve, and to co-author a second paper with Steve and Lee Riciputi of Oak Ridge on the significance of REE in garnets from the Winds and other localities. In addition, Eric co-authored three other GSA talks: one with **Dave Borrok** (MS '97), **Steve Kesler** and others on the Vergenoeg iron ore deposit; one with **Grigore Simon** (PhD '98) and Steve on selenide phase equilibria and their applications to Se deposits; and one with **Peter Tropper** (PhD '97) and Craig Manning of UCLA on experiments that relate to the high pressure stability of glaucophane.

A few family notes — **Zach** (6) has just begun kindergarten, **Adam** (8) is doing very well in a rock climbing course and in school this fall, **Karen** (26) is a social worker and a skilled rock climber in Missoula, **Michelle** (28) is a fourth year medical student at UM (Minneapolis), and **Joyce Budai** (PhD '84) is working on Quaternary methanogenesis in the Michigan Basin. Joyce, Eric and the boys have just moved to a new house west of N. Maple Rd. in order to generate a new geology ghetto in the area along with **Ben van der Pluijm**, **Sam Mukasa** and their families.

Bill Farrand spent nearly four weeks doing geoarchaeology in Greece this past summer, a week with a survey team on the island of Euboea (east of Attica) and the rest on Crete mapping geology and landforms around a Minoan copper-smelting site. This site is curious in several ways, particularly because there are no known copper deposits on Crete. The site is perched on a small, very windy promontory overlooking the Gulf of Mirambello, an ideal location for natural drafts to fire the furnaces. This year will be Bill's last teaching year, after which he will begin a phased retirement during which he will remain (half-time) Director of the Exhibit Museum of Natural History for three more years—until AD 2000. (That has a nice ring to it!)

Dan Fisher spent most of the summer following the proboscidean trail farther back into the Pleistocene than Michigan sites typically allow. Invited to serve as "visiting scientist" at the Mammoth Site of Hot Springs, South Dakota, he had the opportunity to get chummy with many of the 50 or so Columbian mammoths that had the misfortune to be trapped in a spectacular sinkhole on the southeast flank of the Black Hills. They date from a relatively narrow window in time, about 26 thousand years ago, and represent one of the best population samples of mammoths available anywhere in the world. Of particular interest, they record the state of North American mammoth populations at a time shortly before any significant human impact is likely. As such, they will form part of a 'before and after' comparison that should shed considerable light on the question of what caused the late Pleistocene extinction of mammoths and other large mammals. The immediate objective of Dan's work at Hot Springs was to determine the distribution of season of death of these mammoths, but other paleobiological and paleoclimatic data will be revealed as well.

The summer also brought opportunities to sample other mammoths of the Great Plains and start some exploratory work on the pygmy mammoths of Santa Rosa Island, off the coast of California. **David Fox** joined Dan for the close of the field component of the Hot Springs project, but was otherwise involved

in dissertation work, as was **Lindsey Leighton**. Masters candidate **Josh Trapani** entered the paleo program this fall from SUNY Binghamton, and is planning to work on some aspect of Pleistocene paleobiology.

Chris Hall reports that the argon dating lab has been busy with several projects, including acquiring new data that suggests that there were two pulses of mercury mineralization at the famous Almaden deposits (Spain) that were separated in time by about 60 million years. Other work on a project with **Steve Kesler** that will attempt to date several economically important ore deposits has started, with samples from Nevada gold mines heading off to the reactor for irradiation.

We have also tried out vacuum encapsulated irradiation on volcanic glass, and have shown that ^{39}Ar recoil is not a problem. During these experiments on glass shards of known stratigraphic age, it was found that sample preparation appears to be critical for getting the "right" age. More analyses will be necessary, but if reliable ages can be routinely derived from volcanic glass, the whole field of tephrochronology may be revolutionized.

Work is nearly complete on new software for the MAP-215 mass spectrometer which is being converted to work on neon and the heavier noble gases. Ion counting and software for xenon and krypton is in hand, but neon is a bit more of a challenge. Neon suffers from interferences from argon and carbon dioxide, and given the fact that the isotopic composition of all the gases change with time in the mass spectrometer, it is understandable that neon has been the hardest gas to measure.

Alex Halliday has been doing a fair bit of travelling. He attended the History of Earth's Volatiles meeting in Bristol in August, the Asilomar Conference on Mass Spectrometry in Pacific Grove in September (where he bumped into ex Michiganites **Susan Schwartz**, **Lisa Sloan**, **Jim Zachos** and **Peter Holden** who gave him and Jim Hein a tour of the new building (what a clever idea) at UCSC) and the GSA meeting in Denver in October, where he presented a talk at the SEG Short Course on Microanalytical Techniques and greatly enjoyed meeting with **John Valley**, **Zach Sharp** and **Jon Davidson** again. Apart from travelling and keeping busy with the Geochemical Society for which he has one more year to go as President, Alex says the science has never been busier, better and more diverse and interesting. For example, at the same time as postdoc **Der-Chuen Lee** is awaiting the publication in Science magazine of his latest tungsten isotopic results on the rates of accretion in the inner solar system and the MC-ICPMS is producing exciting new data for the Moon and Mars, another postdoc **John Christensen**, is awaiting the publication in Earth and Planetary Science Letters of his ages of melt inclusions from the Bishop Tuff and producing superb paleo-circulation data for the Pacific Ocean from lead isotopic studies of manganese crusts. **Dan Barfod**, **Chris Ballentine** and **Chris Hall** are now generating excellent helium and neon isotopic data for the mantle, **Xiaozhong Luo** has produced the most precise Th isotopic measurements yet made by using MC-ICPMS, **Mark Rehkämper** is discovering dramatic variability in platinum group element abundances in the mantle using new high precision techniques, **Wen Yi** is acquiring the first highly accurate data for the volatile chalcophile elements tellurium and cadmium in the Earth and **Hailiang Dong** is now dating clays in thin section. We will shortly be joined by two new postdoctoral fellows **Thomas Pettke** from Bern, Switzerland and **Claudine Stirling** from Canberra, Australia. Occasionally Alex likes to be reminded that he is still a field geologist by training and at heart. In August he managed to spend his first (two) days of field work in three years with **Dan Barfod**, Tim Grove (MIT), and **Julie Donnelly** (USGS) at Medicine Lake, California - an unforgettable experience.

Steve Kesler spent part of the summer visiting students in the field, most of whom were working on thesis projects. **Grigore Simon** was at the sediment-hosted micron gold deposit at Twin Creeks in Nevada, working on the distribution and mineralogy of gold. He was joined late in the summer by new student, **John Fortuna**, who began short projects on wallrock chemistry and fault timing, the last in cooperation with **Ben van der Pluijm**, who came along on the trip. **David Borrok** was in the same area working at the Florida Canyon mine, where he gave Ben and Steve a good tour. Next stop was the porphyry copper deposits at Copper Mountain and Afton in British Columbia with **Sue Duly**, who is working on the geochemistry of gold in these systems. That was followed by a visit to the Pend Oreille area of NE Washington where new student **Jim St. Marie** began work on the large MVT deposits there. After that, Steve returned to the Dominican Republic for a brief visit to the Pueblo Viejo mine and a look at Centenario, a new gold discovery. Later in September, he was in Australia as one of several keynote speakers for the Mesozoic '96 conference in Brisbane and field visits to the Parkes porphyry copper-gold district in New South Wales.

Becky Lange's activities over the last six months included two weeks teaching summer field camp at Camp Davis, giving lectures at the University of Cincinnati, Smith College, and the University of California at Los Angeles, and also a trip to the Spring AGU to present data on the thermal expansivity of magmatic silicate melts. Previous uncertainties in melt thermal expansivities ranged between 25-40% and now have been whittled down to 5-6 %. These results played a key role in allowing **Fred Ochs** (working toward his PhD) to take his data on the density of hydrous silicate liquids and derive precise estimates of the thermal expansivity and compressibility of the H_2O component in magmatic liquids. Fred has shown that H_2O is the single most expansive and compressible component in silicate melts, which has significant implications for the dynamics of magma transport to the Earth's surface. Fred's work reveals that just minor concentrations of dissolved water have an enormous effect on the density of basaltic liquids. For example, the effect of adding just 0.4 wt % H_2O to a mid-ocean ridge magma is the same as changing the temperature by ~200 degrees or the pressure by 2 kilobars. **Jean Tangeman** is continuing her work on the transport properties of magmatic

liquids and plans to finish her Ph.D. thesis in 1997. **Sharon Feldstein** is completing the final chapter of her Ph.D. thesis in collaboration with Professor Jim Papike at the University of New Mexico. Sharon is conducting a series of melting experiments on the Leedy meteorite to constrain the significance of its textural and chemical heterogeneity.

Jim O'Neil spent six weeks last summer in Tubingen, Germany and in Lausanne, Switzerland working with **Torsten Vennemann** (recent Postdoctoral Fellow) and **Zach Sharp** (PhD '88), respectively. Torsten and Jim discovered that molecular hydrogen undergoes relatively rapid isotopic exchange with minerals at low-to-moderate temperatures and are exploiting this phenomenon to obtain reliable equilibrium fractionation factors that are necessary to interpret hydrogen isotope variations in nature. Jim returned to Europe in September to serve on the committee for the habilitation of **Christophe Lecuyer** (recent Postdoctoral Fellow) at the Ecole Normale Superieure in Lyon. He then participated in the European Conference on Stable Isotope Geochemistry in Nancy where he presented a paper with **Mark Brandriss** (current Postdoctoral Fellow) on oxygen isotope systematics of laboratory cultured diatoms.

Henry Fricke measured oxygen isotope variations, interpreted to be seasonal, in the tooth enamel of 55 Mya coryphodons, extinct hippo-like animals. These are the oldest preserved variations of this sort measured to date and the documentation of this preservation bodes well for the use of such measurements in paleoclimatology and paleobiology. **Ruth Blake** has completed painstaking laboratory experiments to gain insight into the mechanism by which organisms incorporate organically bound phosphate into apatite. Ruth, who would properly be labeled as a biogeochemist, even cultured her own bacteria to provide necessary enzymes that cleave P-O bonds**. Karen Boven** has jumped headfirst into garbage. She is studying stable isotope relations that develop in leachate and gases produced in landfills that accept municipal waste. Karen hopes to develop sensitive isotopic methods of detection of ground water contamination as well as methods of estimating lifetimes of landfills, an important consideration in the use of landfill methane as an energy source.

Henry Pollack's annual update begins very early in January, when he presented two lectures in the U.K., at Imperial College and University College London. While in London Henry also attended a Geological Society Discussion Meeting on Continental Extension and Breakup. In April he visited the University of Arizona to visit with U-A's Geoscience Department's newly formed Alumni Advisory Board about the fifteen year Michigan experience with our Alumni Board. Shortly thereafter, at the conclusion of classes and exams, Henry and **Shaopeng Huang**, a Research Scientist in the Geothermal Lab, were off to the Czech Republic for a week long conference/workshop on the Thermal Structure of the Lithosphere. This meeting was sponsored by the Czech Academy of Sciences, and convened in the Trest Castle in central Bohemia. In attendance were some hundred scientists from around the world, including **Dave Chapman** (PhD '76), now Associate Dean of the Graduate School at the University of Utah, and **Suzanne Hurter** (PhD '92) of the Geological Survey of Lower Saxony in Germany. The week preceding the meeting Henry and Lana visited Eastern Slovakia in search of Henry's grandmother's ancestral village. In July Henry and Lana accompanied a U-M Alumni Association tour to Alaska, and had the opportunity to visit with **Doug Christensen** (PhD '87) in Fairbanks where he is a professor of geophysics at the University of Alaska. While Henry was in Alaska, **Shaopeng** was in Beijing attending the 30th International Geological Congress and lecturing at the Institute of Geology of the Academia Sinicia, and at the Institute of Geomechanics. A highlight of the fall was intoducing a lab into the Hydrogeology course. For anyone with a yen for returning to their sandbox and mud days of youth, this is just what the doctor ordered. Also in the fall, Henry returned to Arizona for a lecture, and to revisit many friends, including **Joaquin Ruiz** (PhD '83) who is now Chair of the Arizona department, **Sue Beck** (PhD '87) now a professor of geophysics, **George Davis** (PhD '71) and professor of geology, **John Chesley** (PhD '93) now in his third year as a post-doc, and **Lois Roe** (MS '90) now working on her PhD at Arizona.

This past year was quite hectic around the Seismo Lab. The most significant changes are due to the departures of three people: **Jean Johnson** (PhD '95) left Michigan for the lofty atmosphere of the Earthquake Research Institute at the University of Tokyo; Dr. **Saskia Goes** has returned to her native Netherlands in accepting a position in the Geophysics/Tectonics group at the University of Utrecht; and **Yuichiro Tanioka** (PhD '95) and his family moved back to Japan as Yuichiro now has a permanent government job doing — what else — research on tsunamis and earthquakes! Although we miss Jean, Saskia, and Yuichiro, we certainly are happy to see them move on to exciting new positions. Speaking of new positions, we are all quite pleased that **Peter Van Keken** will stay at Michigan as a new Assistant Professor. Peter has been a strong force in our geophysics group - and in the entire department. Peter has initiated several exciting new research projects with student **Debra Tjoa**, as well as with other faculty. One impressive feature is that Peter must be one of the few global-scale geodynamicists who goes to field camp! On the research front, student **Nate Winslow** working with **Larry Ruff** have submitted a paper that seeks the "missing earthquake energy." This on-going story has puzzled seismologists from Japan to Ann Arbor. Nate applies his new method to large deep earthquakes, and he concludes that some energy is still "missing," or that deep earthquakes are surprisingly "sluggish." In the MichSeis arena, student **Nazli Nomanbhoy** and Larry Ruff have begun a new project to develop computer software that bolsters the educational facet of the MichSeis program. In fact, Nazli will travel to an international conference this fall in Singapore to present and promote the MichSeis concept in Southeast Asia.

You can keep track of developments around the Seismo Lab by visiting our web pages at: http://www.geo.lsa.umich.edu/SeismoObs/. Or even better, follow the example of alums **Leonid Zimakov** and **Chris Lynnes** (MS '84, PhD '88) by casually dropping by Ann Arbor. See you next time!

Ben van der Pluijm reports that the past half year has been unusually busy in the service arena. Ben took over 'student support' in the Department, which means that he is involved in many graduate student matters, ranging from recruiting and financial offers to TA (now called Graduate Student Instructor) assignments to annual budgeting of RAs and tuition. The spreadsheet program got a good workout. Over the years, Ben has been involved in University Library matters, which this summer landed him in an ad-hoc committee to explore LSA's role in the University Library, and in turn led to an appointment in the current search advisory committee for a new Director of the University Library. Meanwhile, Ben also spends a lot of time on curricular matters as an elected member of LSA's Curriculum Committee. Serving on this committee has given Ben a (much-needed?) broader perspective of the workings of the University and a liberal arts education in general.

But there is still enough time for fun research. With **Eric Essene**, Ben visited graduate student **Meg Streepey** in northwestern New York, where she works on the kinematic and temporal evolution of the Carthage-Colton shear zone (Lowlands-Highlands boundary of the Adirondacks; see photo showing (l to r) NY survey geologist Yngvar Isachsen, cowboy Eric and Meg). Currently her focus is on Ar dating of biotites, complementing the hornblende work of former post-doc **Jerry Magloughlin** (who started teaching at Colorado State this Fall). Soon after that, graduate student **Nei-Che Ho** returned to campus to prepare several chapters of his dissertation on clay fabrics, using texture goniometry and electron microscopy with Don Peacor and Ben.

Visiting gold mining in Utah with **Steve Kesler** (a lot of rock and a little bit of gold) proved to be a great example of applied structural geology; field skills are still awfully important when listening to the mining geologists and seeing their needs. Later in the summer, Ben went with graduate student **John Harris** to sample fault gouge in the Lewis thrust.

This proved to be somewhat of an adventure as road access was poor (broken bridges, etc.) and the final hike to the sampling area was not trivial. However, the outcrop of fault gouge was spectacular, as was the scenery (see photo of Ben with hand at the thrust contact). Samples were taken by pounding Ocean Drilling Program core liner into the gouge; no hammers needed here. The ODP link leads to the work of graduate student **Leah Joseph**, who is working on fingerprinting

of ocean sediments using physical properties (grain size and magnetic anisotropy) in a joint project with **David Rea**. Finally, **Rob Van der Voo** and Ben's northern Appalachian project continues to give interesting results, some of which bear on newly proposed (but, we think, incorrect) Lower Paleozoic plate configurations that were widely publicized. Post-doc **Conall MacNiocaill** (now at Oxford University, UK) and new graduate student **Allen McNamara** are working on key rock units in New Brunswick and Newfoundland.

Ben also worked on the organization of a 1997 Penrose conference on Continental Interior Tectonics that will be held near Cedar Breaks National Monument. The meeting will include a field trip in the Colorado Plateau region that will be led by Michigan grad and former Alumni Board member **George Davis** (PhD '71). Related to this, GSA Special Paper 308 on the eastern US continental interior, co-edited by Ben, should be available when you read this. If you want to hear and see more, just go to Ben's homepage and its links to people, teaching and research (http://www-personal.umich.edu/~vdpluijm).

An entirely new research topic for **Rob Van der Voo** was introduced by the arrival in the paleomagnetic laboratory of Prof. **Xiao-Min Fang**, of Lanzhou University in China, who came in March to measure his extensive collection of Neogene samples in order to establish a detailed reversal stratigraphy. The ultimate goal of this magnetostratigraphic work is to establish a detailed time-scale for the sediments (loess, paleosols, conglomerates and other fluvio-lacustrine strata) in order to detect the influence of the Neogene uplift phases of the Tibetan Plateau. This uplift, in turn, is of great importance for the climate in Asia, and perhaps even for global climate changes. In an intense effort before Xiao-Min returned to his country in September, three studies were prepared for publication during the past summer, and a fourth summary manuscript is in preparation. Other projects are continuing with a variety of students. **Allen MacNamara** arrived this Fall with an undergraduate degree from Michigan State to do research on displaced terranes in the northern Appalachians in collaboration with **Ben van der Pluijm**, and **Arlo Weil** is measuring an extensive collection of paleomagnetic samples from Devonian rocks in the Cantabrian Arc of northern Spain. **Weiming Zhou** is discovering exciting new things about ocean- floor basalts, in

which tiny titanomagnetites occur in globules that seem to indicate immiscible liquids. The titanomagnetites appear capable of carrying the stable ocean-floor magnetizations, and Weiming's project intends to explore why marine magnetic anomalies decay with increasing age of the ocean-floor basalts, in collaboration with **Don Peacor**. Last year's postdoc **Conall Mac Niocaill** departed for a NERC postdoc in Oxford, only to return to Ann Arbor for several visits this Fall. Not to be outdone by this transatlantic restlessness, long-term paleomagnetic laboratory associates **Josep Pares**, **Trond Torsvik** and **Mike McElhinny** are all returning this academic year for visits of variable duration, and it is even rumored that **Doyle Watts** (PhD '79) will leave Glasgow for an appearance later this Fall in Ann Arbor. Spouse **Tanja** is in good spirits, having retired from the Ann Arbor Public Schools, and sons **Serge** and **Bjorn** are pursuing various post-graduate activities and are doing well also.

The geodynamics laboratory used by **Peter van Keken** and **Deb Tjoa** is the proud new owner of a Silicon Graphics parallel supercomputer. The facility, which is close in computational power to some of the largest computers on campus, will be used extensively for modeling of the dynamics of the Earth's interior. Some recent applications include mixing in the Earth's mantle which is studied in collaboration with geochemists **Chris Ballentine** and **Alex Halliday**. The forward modeling approach helps to expand the conceptual ('cartoon') models based on observations into physically plausible models, where the boundary conditions given by geochemistry and geodesy are taken into account.

In late August, **Bruce Wilkinson** and grad students **Kelly Fuks** and **Nate Diedrich** invaded the shoreline of Lake Michigan in an attempt to unearth the secrets hidden in the sediments deposited in estuaries which have developed along the coast. A complex history of downcutting and backfill of these estuaries related to the advance and retreat of glaciers and attendant changes in lake levels and drainage patterns has been recorded in the sands and muds deposited in these systems. The samples and data collected during the trip will serve as the basis for Kelly's Master's thesis. Bruce: Project Coordinator; Kelly: Research Director; Nate: Slave Labor.

Kelly and her husband tested the bonds of marriage during a number of preliminary scouting trips and identified three estuaries that were best suited for the study. At this point, Kelly wishes to acknowledge the saintly patience and Herculean strength of her loving husband. (Steven, in turn, wishes to express his recently developed personal distaste for Lake Michigan estuaries.) Thus it was, that on Manistee, Pentwater and Duck Lakes, the final assault began. Bottom samples and cores were taken and wash-down holes drilled in each of the lakes during the course of the week with some surprising results. Most important was the discovery of significant thicknesses of lake bottom muds below the delta sands deposited at the mouths of the rivers leading into Manistee and Pentwater Lakes. These muds are positive evidence for a lake level rise that generated sufficient water depth for the accumulation of these types of sediments. The muds were not present at Duck Lake which is much smaller and in which appreciable water depths were never developed. However, the absence of these deposits cleared the way for another breakthrough; reaching Pleistocene basement sediments in Michigan, a first for Dr. Wilkinson and another milestone in a long and storied career.

Perhaps the most unusual aspect of the trip was the elaborate system designed by the good Doctor for collecting data in lacustrine settings. It is truly the stuff of legend. The base of operations was the t(rusty) pontoon boat, the R.V. Henry Clifton, named for the eminent sedimentologist, H.C. Sorby. Extensive renovations (a few small screws and some superglue) transformed the aging warrior into a mighty vessel capable of pinpoint maneuverability and top speeds of at least 5 knots. On-board equipment consisted of a water pump, a self-styled tripod and pulley apparatus and what appears to be the remains of the world's most dysfunctional plumbing outfit. All manner of hoses, tubes, pipes, fittings and buckets are crammed into every available space. To everyone but Bruce's immense surprise, the whole thing works pretty darn well. Various combination of items can produce drop cores, push cores, or wash-down "cores" through an opening in the center of the deck. Incidentally, this opening also provides a convenient conduit to the bottom of the lake for all sorts of really useful things. Ask Bruce about the two pipe wrenches.

Overall, however, the trip was a great success and a lot of fun. The residents of posh Pentwater Lake will never forget the image of three drenched geologists screaming at each other on an ancient pontoon boat while thousand year old mud spews forth from a PVC pipe twenty feet overhead. Needless to say, we received some strange looks from the occupants of the million dollar yacht moored nearby. No one ever said geology was glamorous. Until next time...

Youxue Zhang and students had a fruitful summer. Congratulations to **Liping Wang** who published his first paper (his MS thesis) with Youxue and **Eric Essene**. Liping is working on several projects, including the incorporation mechanisms of water in mantle pyrope, and mineral inclusions in pyrope brought up in ultramafic diatremes in the Four Corners area. He discovered a new mineral, for which we are considering the name "carmichaelite" (not officially approved yet) in honor of Prof. Ian Carmichael (PhD advisor of Prof. **Becky Lange**) of UC Berkeley. **Aparna Pydiyar**, an undergraduate student under the supervision of Youxue and **Zhengjiu Xu**, worked in the lab on glass properties, with possible applications to the nuclear waste storage program. **Donggao Zhao**, working with both Eric Essene and Youxue, has been investigating kimberlite pipes in the Northwest Territories in Canada. The project is partially funded by the Canadian government. Youxue and **Wenbing Yu** went to the Aeronautical Laboratory at Caltech to carry out more experiments simulating volcanic and lake eruptions. Wenbing spent several more months there after Youxue left. A new student, **Yang Liu**, has just joined the group.

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MS

Elizabeth Veenstra Meyers "Paleomagnetic constraints on Siluro-Devonian Laurentian margin tectonics from Northern Appalachian volcanics"

In Memoriam

Orlo E. Childs, 82, passed away at his home in Tucson on April 21, 1996, after a long and courageous battle with cancer. Orlo Childs was born in Loa, Utah, on March 28, 1914. He pursued a long and distinguished career in petroleum geology and higher education. He received his BS in 1935 and his MS in 1937 at the University of Utah. He completed his PhD in geology at the University of Michigan in 1945.

Dr. Childs' early career included teaching appointments at Weber College, University of Michigan, Colgate University and University of Wyoming. From 1949 to 1962, he served as Exploration Projects Director for Phillips Petroleum Company. In 1962, he directed the research program in Marine Geology and Hydrology for the U.S.G.S. From 1963 to 1970 he was President of the Colorado School of Mines and during this period he also served on federal advisory boards on natural resources and public lands. He also served as President of the American Association of Petroleum Geologists in 1965-66. From 1970 to 1974, Dr. Childs was Vice-President for Research and Special Programs at Texas Tech University. In 1974, he returned to teaching and research and was named University Professor Emeritus upon his retirement in 1979.

Moving to Tucson in 1979, Dr. Childs became Adjunct Professor in the Arizona Bureau of Mines and Geology and directed a ten-year geological research project (COSUNA) on the correlation of stratigraphic charts of North America. From 1980-85 he also served as Director of the Mining and Mineral Resources Research Institute in the College of Mines at the UA. In 1992, he was awarded an honorary doctorate at Weber State University.

Orlo Childs is survived by his wife of 50 years, Elizabeth Swisher Childs, three children and three grandchildren.

Arthur Richards, Sr., Emeritus Professor of Geology at Southern Methodist University in Dallas, Texas, died at his home on Monday, March 18, 1996. He was born February 19, 1909, in Marquette, Michigan, where he earned his BA in Chemistry from Northern Michigan University. From 1930 to 1937 he taught chemistry at Bessemer High School in Bessemer, Michigan, while continuing his education at the University of Michigan during the summers. He received his PhD in geology in 1941, and worked as an instructor in geology at the University of Texas, Austin, 1941-1942. He married Polly Feeney in 1940. He joined the U.S. Geological Survey in the fall of 1942, and served with this organization for the duration of World War II. He joined the geology department at S.M.U. in February 1946, where he served as professor and several terms as chairman of the department. In the latter part of his career he was one of a select group of faculty designated to advise undergraduate students in the University until his retirement in 1974.