NEWS FROM THE SALINIAN BLOCK

Earth Sciences at Santa Cruz

Alumni Newsletter

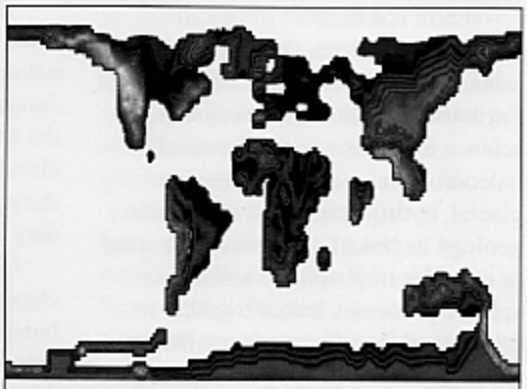
Summer 1999

Predicting the future

Global climate change is on everyone's mind these days, invariably linked to critical issues such as El Niño events, tropical coral reef destruction, rising seawater levels, famines, and floods. Scientists are racing to develop methods to measure the rates and causes of the current trend of global warming, with temperatures projected to rise from 2.5 to 5 degrees C. within the next 50-100 years. Though this rise does not seem like much, a "little ice age" cold snap that peaked from 1570 to 1730 and forced European farmers to abandon their fields was caused by a change of only half a degree C. Precipitation is also predicted to increase—already there is more water in Earth's atmosphere than there was 25 years ago. While some areas will get wetter, others will become more arid. Glaciers and ice caps are melting, and along with the thermal expansion of ocean water, sea level has risen four to ten inches over the past century.

Earth scientists Lisa Sloan, Paul Koch, and Jim Zachos turn to the fossil record for clues from the past to use in conjunction with sophisticated general circulation models to predict the future state of the Earth. Their pioneering work is altering the public's perception of the field of Earth sciences, as these scientists develop methods that provide perhaps the only means of obtaining real numbers to predict how human actions will affect Earth's systems.

The three associate professors use a variety of innovative techniques to gain multiple perspectives of the issues surrounding global climate change. One of Lisa's areas of expertise is fine tuning computer climate models by integrating diverse data derived from the fossil record. Among other sources, she uses temperature data obtained by Jim from oxygen isotope chemistry of ocean sediment cores. Paul's work is complimentary to Jim's, with a focus on diversity and organization of ecosystems on land. Recently, Paul and his graduate students have used the oxygen isotope chemistry of soil minerals (calcite and hematite) and mammal teeth to reconstruct the oxygen isotope composition of rainfall, which is closely tied to mean annual temperature.



Geography and topography reconstructed for the early Eocene epoch, approximately 55 million years ago. The data set was created using a variety of geologic information about uplift rates, sedimentation types and rates, sea level, and subsidence. This information is used as input to the global climate models that Lisa Sloan uses for paleoclimate simulations. Data set created by L. Sloan and graduate students J. Sewall and M. Huber.

Lisa's systems approach to Earth sciences research is relatively new. "I use geologic information to frame specific questions about how and why past climates have evolved, and apply a range of computer models of atmospheric and surficial processes to investigate those questions," says Lisa. In 1998 she received a David and Lucile Packard Fellowships for Science and Engineering, which brings a $625,000 award over the next five years. She will use the award to focus on more completely defining quantitative relationships between observable processes and conditions, from both modern and ancient records, and will expand her research by hiring postdoctoral researchers and programmers and acquiring more advanced computer systems.

"I get to play with data and concepts from a lot of different fields, but my work has to be equally strong in all of those fields," says Lisa. "This is one of the stress points in being in an interdisciplinary field." But it's an advantage, too, she says. "It lets me see things differently because I don't look at just one part; I can see connections between them and have a wider view, and come up with hybrid ideas that can explain things."

When Lisa was first doing her doctoral work in 1990 only a few graduate students were trying out a

(continued on page 2)

Future

(continued from page 1)

systems approach. Since then the number of jobs has grown enormously, and the approach has become a core part of understanding system modeling. Lisa's award was the first Packard Fellowship ever in this area of research and signifies recognition of the field.

Earth System science

"Earth is a number of linked systems," says Lisa, "and Earth system science is an evolved way of looking at Earth through time." Earth system science incorporates geochemical, palcontolgical, geomorphological, glacial, hydrological, and sedimentary geology as linked processes. "We need to consider tropospheric and stratospheric processes linked together to understand the effects of greenhouse gases at Earth's surface over geologic time."

Her current goal is to understand and quantify how surface processes operated under conditions of extreme warmth. She is looking at conditions in the last major warming period on Earth, the Eocene period approximately 55-36 mya. During this period, crocodiles lived within the Arctic Circle, and palm trees grew in what is now Wyoming. Her research ferrets out indications of possible critical factors that influenced the climate at that time, but the circumstances that allowed the evolution of such a climate remain unknown. "I believe that sea ice plays a key role in these processes through nonlinear feedbacks to temperature and radiation conditions, but the actual processes and boundary conditions related to this are currently undefined."

"The current debate concerning global warming is not whether global climate change is occurring," says Jim, "it's whether the warming is caused by the rise in greenhouse gases." Greenhouse gas levels have been relatively low over the last 100,000 years, but show a steady increase over the last 100 years.

"What we learn is that there has never been a time when change was not occurring, that the history of the Earth *is* global change," emphasizes Lisa. However, over large time intervals there is periodic variability, and if scientists can define this periodicity, then it is possible to identify the perturbations and see the extremes. Only recently have the data sets become available that are long enough with enough detail to begin documenting natural variability.

"The time periods we are interested in were times of extremely high natural greenhouse gas conditions," Jim says. "We reconstruct aspects of the atmosphere, ocean temperature and circulation, and hydrologic cycle during these periods and look at how they differ from the present."

Characterizing extreme climate changes provides a clue as to how the biosphere responds to changes in extreme climate conditions. "We see two types of response: one is biogeography, which is to be expected. Both marine and terrestrial species shift in response to climate change, with subtropical flora migrating to higher latitudes," explains Jim. The other change takes place over longer periods of time, and is reflected in the physiology of organisms' responses to temperature and atmospheric changes. "For example, with the more extreme climate perturbations, species which were previously isolated come into contact with each other resulting in extinctions."

Another facet looked at by the group is how fast the system recovers. Adjustment to a new equilibrium is not always immediate—it may take hundreds of thousands of years, with an abrupt response to climate change then a gradual recovery.

The study of climate change used to be in the domain of meteorologists, but it is fundamentally linked to Earth sciences. "Climate is a product of surface processes, and surface processes express climate," says Lisa. These surface processes provide the only record we have of past climates.

"Over the past 20 years, as exploration for new resources has tailed off, most of us see the goal of Earth sciences as understanding all aspects of the Earth," says Paul.

Paul reconstructs climate on land during this time period to show how it responds to global forcing as seen in the marine record. Continental records are more spotty, not as well developed, because they are limited to deposits in basins between mountains. "The marine record is well developed from the long cores we can obtain—but movement on the continents makes it harder to see the undisturbed record," he explains. His results have indicated that the warming ocean in the late Paleocene corresponds to warm events on land and the arrival of primates and two major hoofed mammals. "The climate allowed them to migrate and release all over North America."

"The lesson is, that with global change, it's naïve to believe that the same changes will happen everywhere," says Paul. Developing a model is a good way to see where the differences may be.

"The planet's climate shape will change, but we can't at this point predict how it will change in particular locations," Paul says. And there are differences between now and 55mya, when there was no ice and the world was already warm. The net result was a relatively smaller climate response. Now, the planet is cooler, CO2 is higher to begin with, and we have large ice caps at either pole. The main difference will be caused by the melting ice caps—how will that affect global climate and life on Earth? How will the animals respond—move, go extinct, or both? How quickly can ecosystem reorganize? "We are developing methods to figure out why these things happens, what happens before, and what happens after."

Geochemists, geophysicists, and geobiologists must work together to answer these questions. "We can't research climate without an understanding of plants, moisture, and greenhouse gases," Paul states.

—Julia Davenport

Note from the Chair

Dear Alumni and Friends,

As I pause to reflect on the exciting changes that have taken place over the past few years, I am struck by the number and scope of important events that have taken place. Let me convey a few developments to you.

Our faculty size is at its all-time high of 20 professors, due to addition of two senior-level professors of great stature: Marcia McNutt joined our faculty in 1997, and Gary Glatzmaier in 1998. They are featured in the New Faculty section of this newsletter.

Andy Fisher, Paul Koch, and Lisa Sloan have all been granted tenure, with dramatic accelerations in the process as a result of their superb achievements. This leaves the department with no untenured faculty, but we hope to have some new recruitments in the near future.

Many faculty received prestigious awards over the past 3 years. Among them, Paul won the 1997 Schuchert Award of the Paleontological Society of America, and Lisa received a 1998 Packard Foundation Fellowship (with a $625,000 grant attached). Russ Flegal won a 1998 Outstanding Teaching Award, while Quentin Williams was honored with a 1999 Phi Beta Kappa Teaching Award. Gary Griggs and myself received Outstanding Natural Sciences Division Faculty Awards in the last two years, joining earlier recipient Jim Gill to bring our department total of these honors to the highest of any program in the division. Casey Moore has just been honored as the 1999 Outstanding Alumnus by UC Santa Barbara's Geological Sciences Department.

These faculty achievements reflect, of course, the collective contributions of many students and staff. Mary Hogan has joined our technical staff, replacing Geoff Koehler in the Stable Isotope Mass Spectrometer Laboratory. Together with Ed Boring, Peter Holden, Walter Schillinger, Dan Sampson, and Bruce Tanner, the department enjoys superior technical support for its extensive laboratories and equipment. The office staff has also seen growth with the addition of Carolyn Simmons and the re-hiring of Donna Della Corte. Together with department manager Roxanne Woodling, Sholeh Shahrokhi, and Cathy Smith, our administrative support is exemplary.

Our curriculum is greatly augmented by the contributions from single-year and multi-year lecturers, notably Gerry Weber, Hilde Schwartz, and Suzanne Anderson. Hilde introduced a new class, *The Natural History of Dinosaurs,* that attracted 184 students in its first offering. Suzanne introduced a new topical class called *Water Planet*, which brought in 55 additional students. These large enrollments helped to propel our 98-99 departmental teaching total to the highest level ever.

We have experienced healthy growth in our undergraduate and graduate student population over the past few years and have developed programs to support their efforts. Our curriculum toward the B.S. degree expanded this year to include undergraduate concentrations in Environmental Geology and Ocean Sciences. The Environmental Geology pathway was formed jointly with Environmental Biology and Environmental Chemistry pathways. Together these comprise a nascent program in Environmental Sciences that should attract many majors. A new joint B.A. degree between the Department of Environmental Studies and the Department of Earth Sciences was also just approved.

Casey Moore has spearheaded the development of the new Earth Sciences Internship Program, which places our strongest majors in regional geological job positions and bolsters preparation of our graduates for the working world. In response to comments from alumni we have also instituted across the curriculum increases in technical writing experience and computer use to broaden employable skills as well.

We anticipate that these curricular elements will accelerate our steady growth in majors, which is now approaching a total of 100 for the first time in more than a decade. We had a special departmental ceremony for Earth Sciences undergraduate degree recipients this spring, which I believe was the first such ceremony ever—it overflowed our large auditorium. This year's 19 incoming graduate students will bring our total to about 65 graduate students.

From this list of activities, I believe you can discern why it has been a pleasure to be chair of Earth Sciences for the past 5 years. I have accepted the invitation to continue for a second term. We have excellent department personnel, thriving research programs, and a dynamic curriculum. Prospects for the future are great, as campus growth brings new resources, and we invite you to stay tuned for new developments.

—Thorne Lay, Earth Sciences

Thorne Lay at the Great Wall of China, 1997.

NEW FACULTY

Gary Glatzmaier

Gary Glatzmaier joined UCSC in 1998 as a Professor of Earth Sciences. After serving four years as an officer in the U.S. Navy teaching nuclear reactor physics, he studied astrophysics at the University of Colorado where he received his Ph.D. in physics. After two postdoc positions, he spent 16 years at the Los Alamos National Laboratory (LANL) developing 3D time-dependent computer models to study the structure and dynamics of planets and stars. He also produced computer simulations for pre-flight studies and post-flight analyses of a rotating fluid dynamics experiment flown aboard NASA Space Shuttles in 1985 and 1995. In his studies of geodynamics he has simulated global circulation and convection in the Earth's atmosphere, mantle and core.

Gary's recent research focuses on the Earth's core. He produced the first dynamically-consistent computer simulations of the geodynamo, the mechanism in the Earth's fluid outer core that maintains the geomagnetic field. The simulations span more than a million years, using an average numerical time step of 15 days. At the surface of the model Earth, the simulated magnetic field has an intensity, an axial dipole dominated structure, and a westward drift of the non-dipolar structure that are all similar to the Earth's. The model's solid inner core rotates slightly faster than the surface of the model Earth; this computer modeling result in 1995 served as a prediction for the Earth that seismic analyses now support. Several spontaneous reversals of the magnetic dipole polarity also occur in the simulations, similar to those seen in the Earth's paleomagnetic record.

Gary served on the executive committee of the Institute of Geophysics and Planetary Physics at Los Alamos for 12 years and has been an associate editor of the Geophysical and Astrophysical Fluid Dynamics journal for 10 years. He is a fellow of LANL and the American Geophysical Union and in 1996 won IEEE Sydney Fernbach Award for his geodynamo simulations.

Gary Glatzmaier

Paul Koch

Marcia McNutt in a one-woman submersible.

Paul Koch

Paul Koch joined UCSC in 1996 as Assistant Professor of Earth Sciences. He received a B.A. from the University of Rochester and a M.S. and Ph.D. from the University of Michigan. Paul explores the influences that climate exerts on the diversity and organization of continental ecosystems. He approaches his research from three different perspectives:

First, he develops new techniques to reconstruct paleoclimate on land in the distant past. Paul's group has used the oxygen isotope chemistry of soil minerals and mammal teeth to reconstruct the oxygen isotope composition of rainfall, which is closely tied to mean annual temperature. In their studies of climate change in the Rocky Mountains across the Paleocene/Eocene boundary, they have shown that the first appearance of several major groups of plants and animals is closely linked to local climatic warming. With Jim Zachos, Paul has demonstrated that the episodes of warming in the Rocky Mountains correspond to relatively brief intervals of high-marine temperatures, and mammalian migration and evolution may be directly modulated by rapid changes in global climate.

Second, to evaluate the links between climate change and faunal evolution, he studies the ecology of extinct animals and plants using biogeochemical, microstructural, and morphometric techniques. He used carbon isotopes to examine how the diets of mastodons, mammoths, and other species changed during the rapid deglaciation at the end of the last ice age. Sudden changes in floral composition, driven by climate change, may have driven these animals to extinction. He and his students have been studying the migratory behavior of ancient land mammals, using strontium isotope chemistry. They have turned their attention to marine mammals, exploring changes in the last few thousand years in the ecology of seals along the California coast, as well as the diets and habitats of much more ancient marine mammals.

Lastly, Paul uses these same biogeochemical approaches to study modern organisms to address questions in modern ecology and conservation biology. He has been using isotope variations to assay current and historical patterns of resource and habitat use by modern African elephants, which has ramifications for a proposed method of monitoring ivory trade. Similarly, his group has developed isotopic methods for distinguishing the foraging locations of modern seals, sea lions, semi-aquatic and estuarine mammals in the Pacific Ocean.

Marcia McNutt

Marcia McNutt, President and CEO of the Monterey Bay Aquarium Research Institute (MBARI), joined the Department of Earth Sciences as Professor in 1997. Marcia, former holder of an endowed chair at MIT, is on leave from UCSC during her tenure at MBARI.

Marcia received her Ph.D. in Earth Sciences from Scripps Institution of

(continued on page 5)

Alumni Updates

Ben Benumof (PhD 3/99) Consulting Geologist for Cotton, Shires & Assoc., Los Gatos, CA. **Mike Berg** (BS 9/98) is with Ninyo & Moore Geotechnical & Environmental Science Consultants in Irvine. **Katharina Billups** (PhD 6/87) Postdoctoral position, Princeton. **Wayne Bloechl** (BS 12/92; MS 6/96) is teaching at Cabrillo College.

Debra Carlo (MS 6/98) Geophysicist, Exxon Exploration Corp., Houston, TX. **Chris Castelli** (BS 6/98), **Lisa Darty** (BS 9/98), and **Chris Hundemer** (BS 12/96; MS 6/98) are all working for the Santa Clara City Water District. **Darren Croteau** (BS 8/97) is working for the Orange County Water District. **Alex Densmore** (PhD 6/97) Lecturer, Dept. of Geology, Trinity College, Dublin Ireland.

Maya Elrick (BS 12/81) is an Associate Professor at the University of New Mexico. **Ollie (David) Eisman** (BS 9/98)is at United Space Alliance, Houston, TX. **Jon Erskine** (MS 12/98) is with Geomatrix in San Francisco. **Cristi-Ann Farrell** (BS 6/99) Assoc. Geologist for SCS Engineers, Long Beach, CA. **Gina Frost** (PhD 9/94) is a researcher with the paleomagnetic group at SOEST, University of Hawaii, Oahu.

Priya Ganguli (MS 9/98) has obtained a research staff position in Environmental Toxicology at UCSC. **Stuart Gilder** (PhD 12/93) now has a tenured research position at Institut de Physique du Globe in Paris with the Laboratory of Paleomagnetism and Tectonics. **Lou Gilpin** (PhD 9/95) has his own consulting business. **Lindsey Gipe** (BS 9/98) is an Environmental Health Specialist with San Mateo County. **Jonathan Glen** (6/94) is a postdoctoral researcher at the Berkeley Geochronology Lab and in the Institute of Tectonics at UCSC. **Andrea Goodman** (BS 6/97) and **Leanne Roberts** (BS 9/97) are at the USGS, Menlo Park. **Rich Gunderson** (BS 6/81; MS 9/83) is now Geothermal Exploration Manager at Unocal.

Greg Hancock (MS 95; PhD 6/98) is now on the faculty of William and Mary College. **Peter Haeussler** (PhD 3/91) has a permanent position with the USGS in Anchorage. **Fred Hochstaedter** (PhD 6/91) is an Earth Sciences instructor at Monterey Peninsula College. **Aaron Johnston-Karas** (BS 6/98) is a geologist with Granite Rock. Both **Rolf Lingens** (BS 6/97) and **Erika Wise** (BS 6/97) are working at RRM, a consulting and environmental geology firm.

Attendees to the Earth Sciences undergraduate degree award ceremony in June included (l to r.) Suzanne Holt, co-founder of the Weber/Holt Fund; Hilde Schwartz, alumna and lecturer; Kathryn Sullivan, alumna and astronaut; Gerald Weber, alumnus and lecturer; and recent graduate Julie Friedman.

Craig Lundstrum (PhD 6/96) is an Assistant Professor at the University of Illinois. **Brian McAdoo** (PhD 3/99) is a Lecturer at Vassar College. **Rich McDonald** (BS 6/90; MS 93) is back with the USGS in Denver working on river mechanics. **Kate McIntyre** (PhD 12/98) Researcher, Marine Science Institute, UCSB. **Laura Moore**, (PhD 3/98) Postdoctoral position, Woods Hole Oceanographic Institute, MA. **Bonnie Oglivie** (BS 9/99) Geologist for Petra Geotech, San Diego CA. **Sheraz Omarzai**(PhD 12/96) is teaching Physics at Cabrillo College. **Kathleen Ort** (BS 6/81) is Editor in Chief at Mountain Press in Missoula, Montana.

Judy Totman Parrish (MS 9/77; PhD 9/79) who is a Professor at the University of Arizona, recently published a text book, *Interpreting Pre-Quaternary Climate from the Geologic Record*. **Ben Pink** (BS 8/96; CWMS 6/98) is at ClearWater consulting in Oakland. **Ignacio Rivera-Duarte** (PhD 12/95) has obtained a research position with the US Navy Environmental Sciences Division in San Diego, CA. **Nan Rosenbloom** (MS 9/92) recently completed her PhD at the University of Colorado.

Erik Scherer (PhD 9/99) has a postdoctoral position at Muenster University in Germany. **Eric Small** (PhD 6/98) has a faculty position at New Mexico Tech in Socorro. **Roxanne Smith** (BS 6/97, CWMS 6/98) is now Lab Operations Supervisor at Daniel B. Stephens & Associates in Albuquerque, N.M. **John Stanley** (BS 9/97) is working for Dames & Moore in San Francisco. **Philip Stauffer** (PhD 3/99) Geophysicist, Los Alamos National Lab, NM.

Philip Teas (PhD 9/98) Geologist, Unocal, Houston, TX. **Deborah Underwood** (MS 12/98) Geophysicist, USGS, Menlo Park, CA. **Erika Wise** (BS 6/97) Environmental Scientist, Tetra Tech EM Inc., San Francisco. **Peter Weiler** (PhD 3/99) has postdoctoral fellowship at the University of Montpellier, France. **Xixi Zhao** (PhD 12/87) was promoted to Associate Researcher at the Institute of Tectonics at UCSC. **Rebecca Zisook** (BS 6/98) has a position with the U.S. Forestry Department in Oregon.

Research expansion

A significant effort this past year was invested in preparing a ten-year strategic plan for the department. Coming on the heels of a very positive external review of our department in 1997-98, the faculty developed an ambitious vision of departmental growth to 28 faculty, with concentrated recruiting in planetary sciences, regional climate dynamics, and remote sensing.

The focus on planetary sciences is being nurtured under the newly created Center for the Origin, Dynamics and Evolution of Planets (CODEP), which involves strong collaborations with the powerful Astronomy and Astrophysics Department, Lick Observatory, Physics Department, and Applied Mathematics and Statistics Department. Discovery of extrasolar planetary systems and data from a sequence of planetary flybys in our own solar system have provided great excitement and opportunities for understanding planetary formation and evolution in which our department wants to play a leading role.

The Center for Dynamics and Evolution of the Land-Sea Interface (C.DELSI) has been established to address the complex interactions of ocean, terrestrial and atmospheric systems along coastlines. This involves strong partnerships with ocean sciences, environmental toxicology, marine biology, and environmental studies programs. Understanding regional scale climate systems and the ecological response to climate change is one of the major challenges for Earth sciences in the next millennia, and C.DELSI will position UCSC for leadership in this area.

Both CODEP and C.DELSI are to be organized under the umbrella of a new UCSC branch of the UC systemwide Institute for Geophysics and Planetary Physics (IGPP), which has just been approved for funding by the UCSC administration. IGPP is a prestigious research organization with branches at UCLA, UCSD, UC Riverside, and Los Alamos and Livermore National Labs. Our hope is that the establishment of IGPP, CODEP, and C.DELSI will bring 6-7 new faculty positions to our program in the next 3 years. Plans for expansion of IGPP include a Center for Remote Sensing, which should bring us an additional faculty member with expertise in new technologies used to study geological processes.

One other major activity of the past few years has involved the establishment of UCSC's first industrial consortium by researchers in the Institute of Tectonics. The Wavelet Transform on Propagation and Imaging (WTOPI) consortium, headed by Researcher Ru-Shan Wu, involves partnerships with ARCO, Conoco, Exxon, Norsk Hydro, Shell, CNPN/GS, Elf, Mobil, Schlumberger Cambridge Research, and SUN Microsystems. This thriving enterprise is producing breakthroughs in seismic exploration methods. SUN Microsystems has just made a major donation to the effort, in the form of a radically discounted 8 processor Enterprise system, now the most powerful computer in our program. We expect all the acronyms to become quite familiar to you as these programs thrive!

—Thorne Lay, department chair

Fort Ord Environmental Research

In order to gain experience with the technical skills and research problems related to environmental remediation projects, departmental staff and students have followed some alumni to the Superfund Site at the former Fort Ord. Alumni have worked there for years as consultants on site characterization projects through firms such as Harding Lawson Associates and Dames & Moore. Over the last two years, departmental personnel have put some of the consultant's work into electronic GIS-referenced files, and carried out additional surface seismic reflection profiles, vertical seismic profiles, well logging, and pump tests. During this summer they will synthesize the geophysical and hydrogeological information into an integrated model of the subsurface beneath the Main Garrison.

The Department of the Army has funded the project. Jim Gill, Andy Fisher, and Eli Silver are the principal investigators. Postdoc Steve Lewis, graduate students Jon Erskine and Deb Underwood, and several undergraduates have worked on the project. One undergraduate was especially important—Andy Chaney, an ex-Marine certified to work around unexploded ordnance, who surveyed all shotpoints for the seismic work!

The project will continue for another three years. The next phase will include installation of a groundwater field laboratory containing a nest of flow direction and other sensors embedded within a field of extraction and monitoring wells on university property at the former base. By the end, the Army will have invested over $3 million in the project, about 1/4 of which went to the department for equipment, salaries, and operating expenses. The rest has gone to partners at Berkeley and the national labs for related work.

So, be careful even after you graduate because the faculty may still be evaluating your work! In this case your work withstood scrutiny pretty well. Alumni interested in this project, especially those who have worked at Fort Ord or on regional hydrogeological projects, are encouraged to contact Jim Gill (jgill@es.ucsc.edu).

Dear Alumni,

Please take a moment to let us know where you are and what you are doing. Mail your comments to: Roxanne Woodling, Dept. of Earth Sciences, UCSC, Santa Cruz, CA 95064.

Email responses may be sent to: roxanne@emerald.ucsc.edu. Thank you.

Name _____

Mailing address (home or business?)_____

_____

Telephone _____

Email address _____

Employer _____

Responsibilities _____

_____

_____

Recent achievements, news, etc. _____

_____

_____

_____

Can you tell us anything regarding the whereabouts and activities of other UCSC alumni in Earth Sciences? Suggestions for future activities? _____

_____

_____

_____

EARTH SCIENCES AT SANTA CRUZ

Summer 1999

Earth Sciences at Santa Cruz is published by the Earth Sciences Department, University of California, Santa Cruz, for its alumni and friends.

Editors:
Ken Cameron
Julia Davenport
Roxanne Woodling
Layout:
Julia Davenport

http://www.es.ucsc.edu
831/459-4089
831/459-3074 (fax)

Department of Earth Sciences
Earth and Marine Sciences Building
University of California, Santa Cruz
1156 High St.
Santa Cruz, CA 95064

Address Service Requested

Nonprofit Organization
U.S. Postage
PAID
University of California