NEWS FROM THE SALINIAN BLOCK

Earth Sciences at Santa Cruz

Fall 1996

Tomorrow's Earth Scientists Develop Skills for a Changing Field

by Bob Schultz

Amidst the erection of new buildings, the assemblage of new labs, and the near-completion of UCSC's "Science Hill," an entirely different but equally fundamental set of changes have also been taking place in undergraduate Earth sciences education. A new series of courses--the Earth Sciences Foundation Courses--now ushers new geology students into the major.

Once students leave the university, they will face a reality completely different from that of the past. The primary jobs for geologists are no longer in oil, mining, and with the USGS. Today, many geologists work in fields where soft rock geology is the primary medium and quantitative techniques are essential.

Preparing students for today's world, UCSC's Earth Sciences Department has done what few geology departments in the world have succeeded in doing; it revised its undergraduate curriculum. Associate Professor Bob Anderson, one of the architects of the revision, gestures and draws diagrams on his office chalkboard while explaining the new system.

Attractive lower-division classes like *Geology of the National Parks* and *Earth Catastrophes* along with the long-time staple *Geologic Principles*, draw undergraduates, many of whom have never been exposed to geology, into the major, says Anderson. From there, all Earth sciences students are routed into a new three-course series of foundation courses. This series is the springboard that sends students down one of three distinct pathways. Though students in different concentrations will sometimes share classes, each concentration holds a distinct set of courses as essential. Finally, he notes, summer field, at the end of a student's senior year, will be the capstone class that brings students of the same year back together again.

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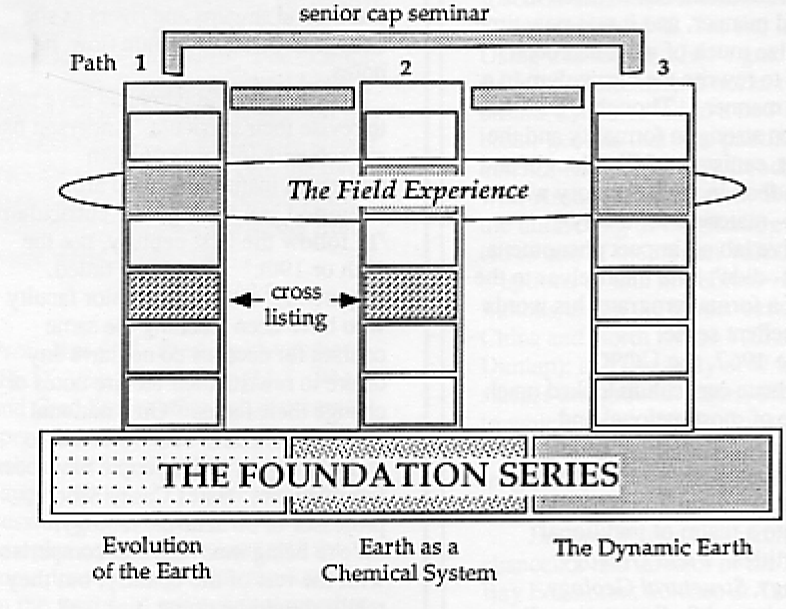
THE NEW EARTH SCIENCES MAJOR



The Foundation Series consists of three new courses, each emphasizing a suite of processes. After completing the series, students select one of three pathways through the major. Many courses are cross-listed between pathways. The field course is cross-disciplinary in nature and strongly recommended to all majors. As a final cross-disciplinary bridge, we hope to offer a cap seminar, in which a particular, multi-faceted issue of the year will be featured. Since 1994-95, we also added a required mentorship course that intends to provide experience with faculty through research activity and analytic labs plus career counseling.

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Working together to rewrite courses and update requirements, the Earth sciences faculty showed the vision of a research institution that really is focused on teaching. At the annual faculty retreat in 1994, Anderson along with Associate Professor Quentin Williams presented the new format for undergraduate Earth sciences education. Breaking into groups at the provost's house, the faculty debated, discussed and, later in the day, helped add to the proposal to construct a new curriculum.

Just as the original faculty came to UCSC dedicated to teaching, the current faculty maintains the tradition. "In part as a result of the way UCSC was born, as an intellectual experiment, the changes have gone through smoothly and shown dedication to educating students," says Anderson. "The [senior] faculty should be roundly applauded," he adds.

"Quentin and I both were disgruntled with the past system," continues Anderson. Their proposal made mathematical rigor a goal of the undergraduate curriculum. "The notion was simple," says Williams, "the Earth sciences curriculum had evolved in a haphazard manner, and it was now time to formalize much of what had been done and to rewrite the curriculum in a cohesive manner." Though UCSC has never been strong in formality and the sling shot, canisters of Playdough, and small sandbox in the laboratory where we spoke--materials for a very quantitative lab on impact phenomena, he claims--didn't lend themselves to the notion of a formal program, his words make excellent sense.

Since 1967, the UCSC undergraduate curriculum looked much like those of most national and international programs in geology. After satisfying basic math, physics, and chemistry requirements, students moved into a realm of traditional geologic titles. *Field Geology, Mineralogy, Structural Geology, Stratigraphy* and *Sedimentation* all found their ways into the majority of students' schedules.

As a department, Earth sciences will never again look the same. The old geology and geophysics pathways to the B.S. degree have been superseded by three concentrations. Students swing into "Oceans, Climate, and Environmental Change," "Surface Processes and Environmental Geology," or "Solid Earth." Traditional geology, as it was, has become a focus inside of the "Solid Earth" concentration.

By the end of an undergraduate's second year as a geology major, each undergraduate is expected to have taken all three foundation courses: *Evolution of the Earth*, *Earth as a Chemical System*, and *The Dynamic Earth.* Once a student has taken the core series, notes Williams, an undergraduate should have all the equipment he or she will need to take most of the upper-division courses. The series focuses on understanding processes and developing the ability to quantitatively approach a problem.

Just as the original faculty came to UCSC dedicated to teaching, the current faculty maintains the tradition.

Williams and Anderson couldn't be more pleased by the makeover. "It's wonderful!" exclaims Williams. Anderson agrees, "Now you see the connections." A scientist needs some of the same quantitative tools to understand streams and rivers as she does to understand mantle flow, he notes.

Many other universities have tried to revise their curricula. Anderson has spoken with individuals from numerous institutions who are interested in updating their curriculum "to follow the 21st century, not the 18th or 19th." Most have failed. Apparently, elsewhere, senior faculty who have been teaching the same courses for decades do not have any desire to rewrite their lecture notes or change their focus. "On a national scale, people have been reluctant to make changes, while people have been flexible here," states Casey Moore, professor of *Structural Geology.* "We're being innovative in comparison with the rest of the country, but they really should be doing it as well. We're 'not way out there', they're just missing the boat," he adds.

Ken Cameron, who has been teaching petrology and petrography classes at UCSC since 1973, sees the new curriculum as a part of UCSC's continual and gradual evolution. "I always see new, interesting things and bring them into my courses," he said. His lecture notes have seldom been exactly the same from year to year so it wasn't particularly difficult to adjust.

His nonchalance comes as somewhat of a surprise since one of the major changes in undergraduate requirements was the removal of *Mineralogy*, one of the traditional "gateways" to a degree in geology, from the list of undergraduate requirements. However, the change is largely one of nomenclature as the new core series still covers the most important mineralogical concepts and material.

"We tried to cut more in the rote memorization," explains Williams. "For instance, how many minerals should an undergraduate be able to identify?" Anderson agrees, "The problem with *Mineralogy* was the focus on memorization, categorization, and lists." He feels that the requirements of such a class did not fit with modern Earth sciences.

The removal of traditional "gateways" to geology, means that students can now get a B.S. without taking *Structural Geology, Stratigraphy and Sedimentation*, or *Field Geology*. Instead, the faculty recommends these courses to students interested in a "traditionally broad background."

In line with the quantitative focus of the core series, the department now requires *Math Methods for Earth Scientist* and *Physics in the Earth Sciences*, emphasizing the mathematical skills and physical concepts most useful to modern practicing Earth scientists. These classes were developed in response to the sense derived from both alumni and students that the more advanced previously required classes in physics and math were less useful than they might be to Earth scientists, explains Williams. "Mathematical and computational techniques used on a regular basis by both industrial and consulting geologists are the focus in Math Methods," confirms Professor Justin Revenaugh, instructor for *Math Methods*.

Keeping pace with the new courses, Moore has adapted *Structural Geology* to include more on the role of structure in active tectonics and by

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gearing toward the relevance of tectonics to hydrogeology and remediation projects. "Those fields are where people are getting jobs, and that's where much of the current research is," states Moore.

Ensuring that the flexibility of the new curriculum is met with ample background in the fundamentals of geology is the faculty's current goal. "I'd like to see [the quantitative focus of the new curriculum] complemented with field data and facts," says Moore, "The tactile side of geology has drawn many students to the discipline, so I see that as the next step."

Updated advising of undergraduates is also part of the next step. Currently, 34 percent of Earth sciences majors have committed themselves to the "Solid Earth" concentration, 48 percent moved into the "Surface Processes" concentration, and 6 percent chose the "Oceans, Climate, and Environmental Change" concentration. The 34 percent enrolled in "Solid Earth" are the only students whose graduation requirements completely overlap with the prerequisites for Summer Field. Consequently, the department puts in extra effort advising undergraduates to fulfill Summer Field's prerequisites, ensuring that the enrollment in this integral part of the curriculum does not decline.

Extra effort across the department is what allowed UCSC to become one of the first universities with an updated Earth sciences curriculum. The concentrations, core series, and rewritten courses, however, are only the first step. The end product will be graduates with new tools, new approaches, and new perspectives on the Earth sciences.

Bob Schultz received his Earth Sciences B.S. in 1993 from UCSC, then worked as a consulting geologist until returning to complete his M.S. with Bob Anderson in geomorphology.

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Your perspectives on the skills an Earth sciences undergraduate should develop are welcome. Write, email, or call

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For more information on the department and courses please refer to web site:

http://glass.ucsc.edu/HomePage.html

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Updates on Some of the Earth Sciences Faculty

How the magnetic field reverses polarity remains an active focus of Prof. **Rob Coe's** paleomagnetic research group. In this regard, Postdoc Pierre Camps, long-time colleague Dr. Michel Prevot, and Rob returned to Steens Mountain, Oregon, to collect still more samples of the Miocene lava flows exposed there that have yielded the world's most detailed volcanic record of a geomagnetic reversal. The purpose of this trip was to extend our sampling laterally in order to test our earlier findings which suggested that an astonishingly rapid jump in field direction (6 degrees per day!) occurred during cooling of one of the flows. If real, these rapid rates will have significant implications for how the geodynamo generates the field. Pierre is working on these samples in the lab right now--we'll keep you posted.

Much of the research of Prof. **Russ Flegal's** group recently has focused on the sources and cycling of contaminants in San Francisco Bay, coastal waters of the Southern Calif. Bight, and oceanic waters in the Atlantic. These studies have revealed the relative importance of metal releases from contaminated sediments. For example, the amount of metals released from sediments in South San Francisco Bay are often an order of magnitude greater than the amount carried into the bay from rivers, and the sediment inputs often meet or exceed the inputs from waste water discharges.

Prof. **Jim Gill**, Fred Hochstaedter (Ph.D. '91), Terri Cook (M.S. '94), and Grad Student Sue Schallenberger spent June 1995 dredging seamounts behind the Izu island arc south of Japan. About 125 dredges were successful with over 1000 volcanic rock samples collected, making this the most densely sampled arc/backarc pair in the world, in spite of foul weather and tenacious targets that frequently shredded chain link bags and broke off all but the last dredge. The rocks are being analyzed and dated, with three undergraduate students for thesis/internship projects.

UCSC has one of two labs in the world capable of high-precision mass spectrometric measurement of short-lived isotopes of U, Th, Ra, and Pa. Using this facility, Jim's graduate students, work on mid-ocean ridge basalts that have led to a new model for basalt genesis that was published in *Science* last year (Craig Lundstrom, with Assoc. Prof. Quentin Williams); the unraveling of magmatic events that led to one of the largest volcanic eruptions of this millenium--from Baitoushan on the border between China and North Korea-- (Charlie Dunlap); and the study of U isotopes in surface and ground waters, the approach to which seems able to fingerprint water and, perhaps, to evaluate the length of time water spends in aquifers (Aaron Reyes).

Jim continues as research vice chancellor and director of the Monterey Bay Education, Science & Technology Center at the former Fort Ord.

Prof **Gary Griggs** is just completing his fifth year as director of the Institute of Marine Sciences which has taken considerably more time than the 50

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Letter from the Chair

Dear Alumni and Friends:

While our Department has now settled into our new building, there have continued to be exciting changes in personnel and facilities. We were very pleased to be ranked as the number 24 Geoscience program in the country in the 1995 National Research Council assessment, making us the third highest ranked graduate program on campus (hats off to Astronomy and Linguistics, which scored in the top 10 of much smaller comparison pools). A proud achievement of the past year was our success in hiring the top choice in each of three faculty recruitments, in competition with other excellent programs. This indicates the continuing health and vitality of Earth sciences at UCSC, as we rebound from the early retirements of senior faculty.

New Assistant Professors Lisa Sloan (Earth System Modeling) and Andy Fisher (hydrogeology) began their appointments in summer and fall of 1995, and have set up laboratory and computing facilities along with initiating graduate student research projects. You can find out more about their interests elsewhere in this issue. Our third hire is Assistant Professor Paul Koch, who arrived summer of 1996, leaving his faculty position at Princeton to come work in the areas of paleontology and paleoecology.* Paul is an specialist in proboscidians, and uses stable and radiogenic isotopes to study mammoths, mastodons and present-day elephants, amongst other research interests. These three faculty additions leave us just one-short of our past peak authorized complement of 19 faculty, and we hope to recruit for that position in the next few years. I expect to see our program rank in the top 15 by the time of the next NRC comparison, given the excellence of our recent hires.

Our technical and administrative staff has also grown, with Dale Whyte joining the front-office administration and Donna Della Corte taking a new administrative position shared between the Department of Earth Sciences and the Institute of Tectonics.

Dr. Peter Holden has replaced Zenon Palacz as the Thermal Ionizing Mass Spectrometer (TIMS) technician, and Dr. Geoff Koehler has joined us to serve as the new Stable Isotope Mass Spectrometer (SIMS) technician. The administrative and technical staff are all critical to the success of our research and teaching programs, and we are again fortunate to have attracted our top choices for each position. The TIMS and SIMS facilities are very impressive and we hope that you have an opportunity to come visit them soon.

We are in the second year of our new undergraduate curriculum, and it appears to be achieving our goals of program excellence and flexibility. Our introductory classes are thriving, with *Oceanography* being offered twice each year now and attracting a total of 350 students, and a new course called *Geology of National Parks* attracting 175 students in its first offering. The graduate program is doing good business, too, with 21 new graduate students (a record size) joining us in 1995.

As the nature of research funding and the job market in Earth sciences evolves, we are striving to enhance applied and industrial research connections as well. For example, Andy Fisher is exploring research opportunities associated with the civilian-conversion of the army base at Fort Ord, Elise Knittle is conducting materials science research on superhard substances, and Researcher Ru-Shan Wu is establishing an oil company consortium for developing seismological methods for three-dimensional elastic wave migration. We encourage our alumni to help keep us informed about job opportunities, research relevance, and possible collaborations with industry that you may know about.

Please let us hear from you and stop by the Department if the opportunity presents itself.

Thorne Lay, Department Chair

*Paul will have an expanded article in our next newsletter.

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percent listed in the job description. He put major effort into expanding the institute and attracting state and federal agency programs to the Long Marine Laboratory in order to develop a national marine sciences center. Federal politics have intervened, however, making this very difficult.

Gary and his grad students, a group of four, continue work on coastal research problems such as the impacts of engineering structures on coastlines, coastal erosion processes and hazards. Gary and Ph.D. Student Laura Moore have been funded by NSF to develop a coastal imaging lab which will include state-of-the-art facilities for documenting landscape change through scanning aerial photographs and processing and interpreting this information. A major time line was crossed this spring when Gary realized that one of his former grad students, a person you all know, Jerry Weber, had retired from his consulting business....retirement!!!

Continued service as department chair and on the campus Committee for Planning and Budget this year by Prof. **Thorne Lay** has, fortunately, not precluded interesting work in seismology, conducted with members of the Global Seismology Program. Grad students of this group continued work on simulating regional phase propagation using finite difference methods for heterogeneous crustal models (Zhengyu Xu); imaging the 3-D shear velocity structure of subducting Pacific plate beneath the Kurile Islands (Kris Eckhardt); and the study of earthquakes in the Western U.S. and Mexico, structure of upper-mantle discontinuities beneath Bolivia, and the core-mantle transition zone under the Pacific Ocean (Jeroen Ritsema, Ph.D. '95). The last was jointly supervised with Ed Garnero, NSF postdoctoral fellow. Ed discovered an intermittent layer of very slow material right at the core-mantle boundary. With Assoc. Prof. Quentin Williams, he infers that partial melting of a mantle constituent is the most likely explanation. Thorne and Ed are pursuing data analyses of this and the general problem of understanding processes in this boundary layer. Other postdoc projects include a recently completed global inversion of surface waves for 3-D shear velocity structure in the mantle (Yu-Shen Zhang); 3-D finite-difference methods for application to site effects (Ornella Bonamassa); modeling 3-D scattering near the core-mantle boundary and 3-D elastic wave migration (Xiao-bi Xie)--the last also with Researcher Ru-Shan Wu. Postdoc Guangwei Fan and Thorne are modeling regional wave propagation in China, to contribute to monitoring of

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a planned comprehensive test ban. The rapid progress on a test ban this year has prompted Thorne to again serve as chair of a National Research Council panel, advising the Department of Defense on how to conduct seismological research to ensure effective monitoring of nuclear testing treaties.

Prof. **Casey Moore's** research continues to focus on fluid rock interactions in structurally complex environments. Grad students in his research group work on the geophysical and hydrologic evolution of the offshore Oregon accretionary prism (Guy Cochrane, Ph.D. '94); the paleoseismology and geomorphology of the Kodiak Islands, Alaska, (Lou Gilpin, Ph.D. '95); and the role of faults forming barriers to fluid flow in the offshore Wilmington oil field of southern California (Phil Teas and Jenny Thornburg)--this project is a cooperative with Jim Sample (Ph.D. '88). Students are also analyzing the effects of gas on tectonic deformation, and slope failure in the Eel River Basin (Janet Yun and Brian MacAdoo)--with Dan Orange (Ph.D. '91) and Sara Foland (Amoco); mapping the structural fabric of the San Gregorio Fault at Moss Beach to determine how it could be imaged in seismic reflection (Meredith Lohr); establishing the orientation of stress around the San Gregorio Fault (Damian Saffer); and studying the Holocene offset history of the San Gregorio Fault (Jenny Thornberg, with Gerald Weber). Barbara Bekins (Ph.D. '93) and Damian have also been numerically modeling fluid flow from the Nankai accretionary prism off southwestern Japan. During summer of 1994 Harold Tobin (Ph.D. '95), Gretchen Zwart, and Casey sailed on an Ocean Drilling Project leg exploring fluid flow along the plate-boundary megathrust. Overall they developed a good picture of the fluid pressure through the prism and the megathrust, its propensity for hydrofracturing and how hydrofractures are imaged in seismic reflection data.

To complement the continuously-operating, high precision GPS (global positioning system she installed on Arenal last spring, Assistant Prof. **Susan Schwartz**, with Grad Students Mike Hagerty and Lillian Soto-Cordero and Instrument Specialist Dan Sampson, spent much of November depolying seismic and ground deformation instruments on Volcan Arenal, an active volcano in central Costa Rica. Three alumni are presently affiliated with OVSICORI-UNA in Costa Rica (Federico Guendel, Ph.D. 1986, Eduardo Malavassi, Ph.D. 1991, and Marino Protti, Ph.D. 1994) and are participating in this collaborative effort with our department. Project goals are to gain a better understanding of the volcanic system and processes, such as the depth and geometry of the magma chamber and the mechanics of magma transport. They also hope to integrate this knowledge with observations of precursory deformation to improve volcano eruption forecasting.

Schwartz continues her work to better understand earthquake occurrence at subduction zones. Grad Student Renate Hartog and Schwartz are studying consecutive large earthquakes that rupture the same segment of the plate interface to determine if they represent characteristic earthquakes or if they break different regions of the plate boundary. Finally, Postdoc Artie Rodgers and Schwartz are investigating seismic velocity structure of the crust and mantle lithosphere beneath the Tibetan Plateau. The very slow crustal velocities that they obtained caused them to propose a new model for crustal thickening and continental convergence in this region.

Professor Emeritus **Othmar Tobisch's** research group continues studies of the structural aspects of granitic rocks mostly in the Sierra Nevada of California, where exposure of the granites and their wallrocks is excellent. The work is being done by Brendan McNulty (Ph.D. 1994) with Profs. R.H. Vernon (Macquarie University, Sydney, Australia), A.R. Cruden (University of Toronto, Canada) and Tobisch. McNulty, supported by a NSF postdoctoral grant awarded to Tobisch, and Cruden are doing anisotropy of magnetic susceptibility studies on the granites to determine the flow patterns in the granitic magma during its emplacement. McNulty, Vernon and Tobisch are studying the distribution and geometry of mafic microgranitoid enclave swarms in the granites to gain insight into the distribution of emplacement conduits within the plutons.

Other research of Othmar's is on the orogenic history of the Aravalli fold belt, Rajasthan, India, with Drs. D.Mukhopadhyay and T.Bhattacharyya (Ph.D. '86), both of Calcutta University, India. They are studying the structural/tectonic/ metamorphic history of this preCambrian fold belt in the western Indian craton which has undergone a very complex series of events during neoArchean to neoProterozoic times. Bobby Lopez (Ph.D. student of Prof. Ken Cameron) is doing zircon geochronology on one of the plutons that intrudes the wallrocks, and to date has yielded very discordant data but indicative of at least two tectono-igneous-metamorphic events. Field mapping, microtextural work and geochronology supports a complex history for this part of the Indian craton.

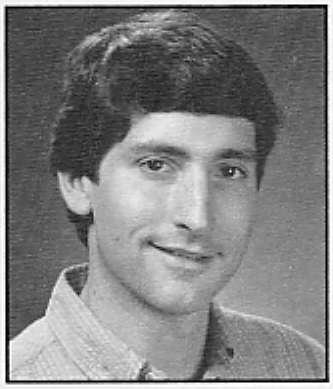
A portion of Assoc. Prof. **Quentin Williams'** recent work has examined the starting and ending points of the plate tectonic cycle: evolving a new paradigm of how the mantle melts to form the basaltic oceanic crust with Grad Student Craig Lundstrom and Prof. Jim Gill, and experimentally probing with Dan Farber (Ph.D. '94) the manner and rate at which the Earth's mantle rehomogenizes subducted ocean crust 200 million years or more after its initial formation at the ridge crest. There appear to be more linkages between these two seemingly disparate areas than Williams would have originally guessed, with much of the chemical variability produced by mid-ocean ridges possibly being produced by the amount of recirculated ocean crust present in the region tapped by the ridge. It looks like a cycle, although it's strikingly inefficient, disorderly, and spatially complex.

NEW FACULTY

Andrew T. Fisher

Andrew Fisher's research focuses on hydrogeologic characterization in a variety of environments, including shallow continental bedrock, accretionary complexes, and ridge-crest and ridge-flank hydrothermal systems on the sea floor. His work includes field, laboratory, analytical and numerical studies of fluid flow and coupled heat and fluid flow.

One of Fisher's active projects is an assessment of relationships between hydrologic properties and sedimentary facies within Pennsylvanian aquifers on the eastern edge of the Illinois Basin in southwestern Indiana. After completion of 200 aquifer tests in 130 wells, Fisher is integrating these results with core descriptions, driller's records, and natural gamma-ray logs. Through inversion of this large data set, Fisher derives facies-specific properties and trends that allow predictive modeling of fluid flow within the shallow subsurface. These results also should allow a better assessment as to how much and what kind of hydrologic data is needed to plan and execute a remedial action.



Andrew T. Fisher

Fisher's research on the flanks of sea floor ridges includes direct measurements of fluid and thermal transport parameters, as well as modeling of large-scale systems to infer likely permeability distributions. Direct measurements and models suggest that the zones of greatest permeability in the basaltic upper crust, where fluid and heat flow are most concentrated, are layers only a few tens of meters thick, typically flow boundaries and intervals of basalt breccia. These studies also suggest that chemically significant flow may continue even within the oldest remaining [Jurassic] seafloor crust. Fisher has conducted surveys on, and modeled ridge flanks within, systems off the Costa Rica Rift, the Galapagos Spreading Center, and the Juan de Fuca Ridge. Future work will include drilling and modeling of the Juan de Fuca ridge flank. Measurements of oceanic heat flow are useful indicators of fluid flow, from sea floor spreading centers (when new crust is created) to accretionary complexes (where old crust is subducted). Studies of sedimented spreading centers, where the oceanic ridge is buried beneath a thick sediment layer, are particularly interesting because this setting offers an opportunity to assess the thermal budget of crustal formation as well as several scales of hydrothermal fluid circulation. Fisher has conducted studies of sedimented rifts in Guaymas Basin, Gulf of California and Middle Valley, northern Juan de Fuca Ridge. Fisher has also studied coupled heat and fluid flow within accretionary systems of the Cascadia Margin, off shore of Oregon; the Nankai Trough, Japan; and the northern Barbados Ridge. These studies reveal strong evidence for the transience of fluid flow in this setting. He and colleagues recently conducted the first successful aquifer tests along a plate boundary fault within an active accretionary system.

Lisa C. Sloan

Lisa Sloan's research interests focus on understanding the processes which have controlled past climates, as well as understanding and characterizing past marine and terrestrial climates, environments, and surficial processes in Earth history. Her research has concentrated primarily on Cenozoic events and processes, with primary emphasis on the warm and transitional intervals of that era of Earth history. Paleoclimatology involves not only the consideration of traditional disciplines such as sedimentary geology, paleontology, and stable isotope interpretations, but also includes less traditional approaches such as modeling of the Earth system with supercomputers. The nature of this research involves examining marine and terrestrial geologic records of climatic and environmental change, and then striving to understand the driving forces behind such changes. To deciper the past Earth systems and their causal factors, paleoclimate models are a powerful tool that are put to use in the Earth sciences research of Sloan's work. She applies models which describe the surface of the Earth, including continental distributions and relief, atmospheric composition, surface vegetation and soil characteristics, to pose and investigate questions addressing past environments, climates and depositional settings. These state-of-the-art models have been used to investigate problems ranging from prediction of petroleum source rock distribution to understanding mid-Cenozoic cooling and drying trends of western North America as recorded by floral, faunal, and sedimentological evidence.

Lisa C. Sloan

One theme of Sloan's research has dealt with the Eocene world, a warm time interval which existed approximately 55 million years ago. Representative geologic evidence indicate global and regional climates with perplexing characteristics relative to the modern world, including forests in the Arctic Circle and crocodilian communities in what is now Wyoming. This research has led to renewed debate in the scientific community regarding the nature of continental interior climates during warm intervals, and also indicates that regional records of climatic and environmental conditions, intimately linked to geologic processes, have important implications for the record of global climate change.

A second theme of Sloan's research is the subject of warm and transitional intervals of climate in geologic history. As one example, within the past 2 years Sloan has been participating in a project investigating the globally warm climate of the middle Pliocene (~3.5 million years ago) led by scientists at the U.S. Geological Survey. This has turned into a major endeavor involving dozens of scientists from a range of disciplines. Pliocene climatic and environmental change is particularly relevant to future climate change because it was a geologically recent warming, with abundant evidence to help decipher important climate processes and responses at that time.

BOON FOR BROKEN BONES

In 1985, Brent Constantz was on a South Pacific atoll near Tahiti, working toward his Ph.D. on how corals make their skeletons. Ten years later, he heads Norian Corporation, a company making waves for its remarkable product: a paste that dramatically speeds the healing of broken bones.

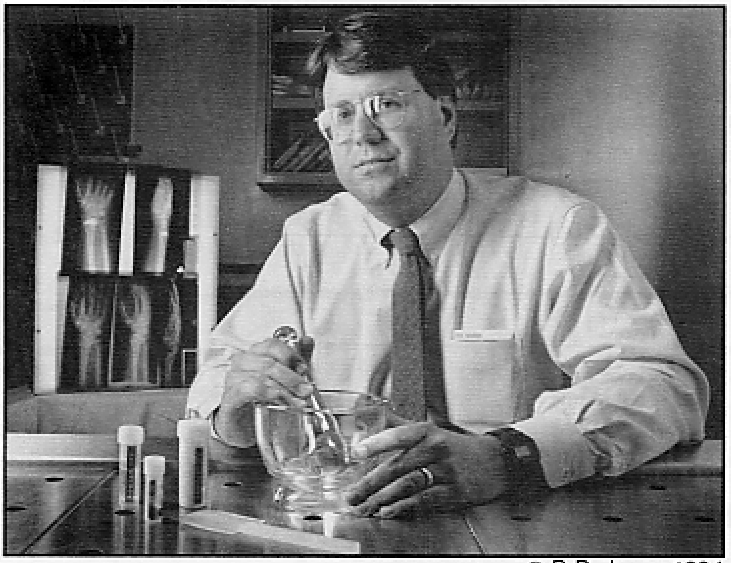
That's not a typical career path for a geologist, but it has earned Constantz more public renown than any UCSC Earth sciences alumnus since Astronaut Kathy Sullivan. The attention is deserved, for his innovation could ease pain and cut medical bills for hundreds of thousands of Americans--especially those with age-related fractures of hips, wrists, and other joints.

Called Norian SRS (for "skeletal repair system"), the compound looks and feels like light-gray toothpaste. Doctors inject it into and around a fracture. The paste forms the same mineral composition as bone and hardens rapidly, matching the strength of natural bone in twelve hours. Gradually, living bone cells replace the implant.

Clinical trials show that Norian SRS helps patients get out of their casts much more quickly--in two weeks for a broken wrist, for instance, instead of the normal six. It could reduce the need for screws, plates, and other costly hardware. Most heartening, it could toughen the bones of people with osteoporosis, a condition of aging that renders bone porous and brittle.

Studies to gauge the long-term performance of the paste are under way. If all goes well, the U.S. Food and Drug Administration could approve Norian SRS for certain uses by 1997.

The media glare on Norian grew white-hot in March [1995], when Constantz and his team published an article in the journal *Science*. Reporters from across the globe called or brought film crews to company headquarters in Silicon Valley. The public was no less ravenous; Constantz received hundreds of letters a day, many from people seeking medical help. When told they could not get Norian SRS here, some flew to Holland, where doctors can use the paste.



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Alumnus Brent Constantz (Ph.D., 1986) parlays his academic research on coral into a promising medical technology

This enthusiasm is easy to explain, Constantz says. "A lot of people love or know somebody who's suffering from bone degeneration," he says. "When they see the potential of Norian SRS, it's so obvious to them how it could help. They don't have to know chemistry or how molecule X works. If they understand basic carpentry and how concrete forms, and if they appreciate that bone is a responsive tissue, they've got it."

Since earning his Ph.D., Constantz has raised nearly $40 million in venture capital to develop Norian SRS. All along, he has kept in close contact with UCSC. He supports the summer research of two students under biologist Donald Potts, a coral specialist, and he donated equipment to the Earth Sciences Department. Several UCSC researchers have worked or consulted at Norian.

Professor Emeritus Léo Laporte, who advised Constantz on his Ph.D., says that his saga reveals how crucial it is for agencies to fund basic scientific research, even if it has no obvious practical spinoffs. Laporte also recalls that when Constantz applied to UCSC, reviewers looked beyond his grades. "Brent had other things clearly going for him, including enthusiasm, imagination, persistence, and a gung-ho spirit," Laporte says. "If we were to admit students only on their test scores or other numerical criteria, people like Brent might get swept aside."

by Robert Irion, UCSC Public Information Officer

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When we contacted Dr. Brent R. Constantz about reprinting of this article which appeared in the summer/fall 1995 edition of UCSC's *Review* magazine, we received this additional information. Brent arrived at the idea for Norian SRS while doing field work for his doctoral dissertation. He became interested in how reef-building corals produce their skeletons, and began searching for a way to replicate this style of mineral growth in human bones. Norian Corporation, incorporated in 1987, is named for the geologic stage in which modern reef building corals first appeared, approximately 200 million years ago. Brent discovered that mixing a calcium compound with a phosphoric acid source and adding a sodium phosphate solution would produce a thick paste that would harden into a material resembling human bone mineral. For several years he and his associates at Norian Corporation refined and tested the product, creating some 1,200 different versions before arriving at the final formula in 1993.

Dear Alumni: Please take a moment to let us know where you are and what you are doing. Thank you.

Name: __________

Mailing Address: (circle: Home or Business): __________

Telephone: __________ email: __________

Employer: __________

Duties: __________

Recent achievements or news: __________

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

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