UCLA
EARTH & SPACE SCIENCES
1996 ALUMNI NEWSLETTER

In this issue...

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Chair's Letter

This has been another exciting year for Earth and Space Sciences. In the Fall, we welcomed three new Rubey Fellows to the Faculty: Dr. Martin Kennedy from Cornell, Dr. Tom LaTourrette from Caltech, and Dr. Laurie Leshin, a President's Postdoctoral Fellow at UCLA. As it turns out, all three are geochemists, but they study very different things. Laurie is famous for her work on Martian meteorites and was able to advise the *LA Times* when the "life on Mars" story broke during the Summer. She was recently on the windswept blue ice of Antarctica looking for more chunks of Mars! Tom studies the behavior of trace elements and volatiles in silicates from both experimental and theoretical viewpoints. He will contribute to the Department's strengths in high pressure experimental petrology. Martin is working on two quite different things: Neoproterozoic glacial environments (Australia and Namibia) and nutrient cycling in old growth forests (Chile and Hawaii). The tools he uses are natural and synthetic stable isotopes, so he is busy rebuilding and renovating the Kaplan Lab's extraction lines and mass spectrometers. It is a great pleasure to have these three new young Adjunct Assistant Professors at the workface.

This does not mean that the permanent Professoriat has not been busy! J. William (Bill) Schopf was catapulted into the limelight in August by the "Mars life" announcement. You may have seen or heard his laudably cautionary views on national media at the time. More recently, he participated in Vice President Al Gore's well-publicized "salon" to discuss the possibilities for the origins of life. Happily, UCLA had just added an extra card to the deck with the discovery, in Mark Harrison's Keck Lab, of light carbon isotope ratios in graphite from 3.9 billion-year-old rocks in Greenland. The close physical association of light graphite with phosphatic apatite points to a biological origin for the metamorphic minerals. This ion probe-based discovery moves the origin of life on Earth uncomfortably close to the period of heavy cratering recorded on Mercury and the Moon.

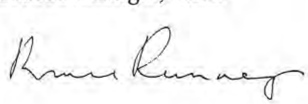
Planetary science moved to center stage earlier in the year as the Galileo spacecraft began a two-year tour of the moons of Jupiter. This time last year I predicted spectacular results, and that they were! Doppler effects in the radio link with Galileo were observed as the spacecraft was slowed up by the gravity fields of Io and Ganymede. This allowed Gerald Schubert and his colleagues to determine that both moons have iron cores. At the same time, Margaret Kivelson and her colleagues showed that both moons have strong magnetic fields. These blockbuster results were presented in two papers in *Science* (May 3 and October 18) and in five articles in the December 12 issue of *Nature*.

There were, however, some major setbacks. The postlaunch explosion of the new Ariane-5 rocket in July dropped our space physicists' payload - four Cluster satellites - into the swamps of French Guyana. They were to have orbited Earth in a tetrahedral array as suggested by the cover of this *Newsletter* (imagine you are riding on the fourth satellite). As Cluster will now go ahead, albeit in a slower and downscaled way, I used a European Space Agency graphic of Cluster (now aptly renamed Phoenix!) for this image.

You may wonder why Australia figures so prominently on the cover? It's partly because Mark Harrison, who will take over from me in April, will be the third Australian Ph.D. in a row to serve as Chair. But it is also because this oceanean image of the Earth exposes Paul Tackley's mathematical mantle plumes much more clearly than the view used on our World Wide Web page. It also highlights the Department's considerable interest in Asian tectonics and the growth of the Tibetan Plateau (red colors indicate high profiles!); work by Jon Davidson's group on volcanoes in Kamchatka; Laurie Leshin's meteorite hunting ground near the South Pole; and Martin Kennedy's between-basalt paleosols in Hawaii. This is the other edge of the Pacific Rim and a frontier for UCLA in the 21st Century.

Contacts with the oil industry continue to improve, and we welcomed old friends bearing generous gifts from Amoco, Chevron, Exxon, and Mobil during the Fall. As a result, several graduate students have been offered internships or continuing positions in 1997. Amoco went even further and has agreed to provide a prize of $500 for the best paper/ best science at the Department's annual graduate student symposium. This one-day event is organized by the venerable Earth and Space Sciences Student Organization so the cheerful outcome is that the Amoco Prize will be the highlight of the ESSSO Symposium!

All the very best for 1997.
Bruce Runnegar, Chair



TOM LATOURRETTE (Ph.D., Caltech 1992) is interested in understanding the origin and evolution of igneous rocks such as volcanic lavas and granitic plutons. Because these rocks form by melting and crystallization within the Earth's interior, he uses high temperature furnaces and presses to simulate the conditions of their formation in laboratory experiments. By comparing the melts formed in experiments with natural lavas, he has found that the sources of all ocean floor lavas must contain the mineral garnet. This discovery requires that either the sources of these lavas begin melting deeper than 70 km or that the mantle is rife with garnet-pyroxenite veins, and has completely revised our thinking about melting in the Earth's mantle. His interest in the influences of volatile components within the Earth has led him to investigate how the addition of water-bearing minerals affects the lavas that form in regions where one tectonic plate subducts beneath another (such as the Cascade Range) and to measure the properties of CO_2 at very high pressures. His newest experiments are aimed at understanding diffusion. By measuring how fast minerals and melts can change composition, he can constrain the rates and timing of a variety of geologic processes such as magma mixing, contamination, and crystal growth. As a Cal alumnus, he's glad to be part of the UC system again.

Once an avid swimmer, he still paddles about in the pool and occasionally slips off to Hawaii to combine two loves - volcano trekking and ocean swimming. He has also been seen moonlighting as a jazz bassist, but plans to keep his day job as well.

Adjunct Assistant Professor of Geochemistry and Geology

Adjunct Assistant Professor of Cosmochemistry

LAURIE LESHIN (Ph.D., Caltech, 1994) is interested in stable isotopic analysis of extra-terrestrial materials on size scales ranging from microscopic to planetary. Her measurements of hydrogen isotopic abundances in Martian meteorites provided the first geochemical evidence for extensive hydrothermal systems on Mars leading to unique insights into the volatile history of that planet. The importance of this work for planetary science was recognized this year by the Meteoritical Society, which awarded Laurie the inaugural *Alfred O. Nier Prize* for an outstanding contribution by a young scientist. Utilizing the UCLA ion microprobe, she has recently performed the first oxygen isotopic analyses of extremely rare olivine and pyroxene grains in the CI carbonaceous chondrites, which may contain the best preserved example of "average solar system" oxygen. As PI for an Origins of Solar Systems grant, Dr. Leshin plans to pursue her studies of early solar system materials further by measuring the microdistributions of oxygen isotopic anomalies in components of primitive meteorites and interplanetary dust. In addition to her laboratory isotopic studies, she is a co-investigator on the *Mars Volatile and Climate Surveyor* (MVACS). An integral part of the Mars Surveyor 1998 Lander, this UCLA-led experiment (Prof. Paige, PI) will analyze the abundance and isotopic compositions of H_2O and CO_2 in the martian atmosphere and in volatiles released from heated soil and ice samples.

A product of the Arizona desert, Laurie enjoys life in Southern California. Following meetings at JPL to chart NASA's solar system exploration agenda over the next two decades, she has been known to relax by rollerblading around the Rose Bowl. As of this writing, she is exploring the world's southernmost desert as part of the ANSMET (ANtarctic Search for METorites) field team. Although with her scientific background, and the press of recent events, she has received numerous tongue-in-cheek requests by colleagues to "bring back more martian meteorites" from the ice, we expect that she will consider the mission a success if she finds some interesting meteorites, whatever their origin, and if, after camping six weeks on the ice, this Sun Devil still has warm toes.

MARTIN KENNEDY (Ph.D., University of Adelaide, Australia, 1994) His research combines field work with geochemical tracers in order to study both modern and ancient biogeochemical systems. Within modern ecosystems in southern Chile and several islands in the Hawaiian chain, he is applying novel isotopic techniques to understand the chemical behavior of important plant nutrients in soils and their origins and pathways into the plant community. There is a very pressing need to understand the effects of airborne pollution/acid deposition on these chemical pathways and this isotopic technique has provided "new eyes" to view the function of this system. The results thus far reveal a striking dependence on the dilute amounts of nutrients arriving within rain rather than those derived from bedrock weathering. This most unexpected result implies that the long-term health of ecosystems is far more sensitive to humanity's effects on atmospheric chemistry than previously believed.

In the ancient rock record, he is integrating detailed stratigraphic studies in central Australia and Namibia with isotopic geochemistry to study the peculiar series of climatic and oceanographic events leading up to the first appearance of complex life. This was a particularly turbulent period of earth history which saw ice sheets on the equator, a considerably different chemistry within the oceans, the building of mountains and the rifting of continents. Through all of this, complex organisims took hold and began modifying their environment. His interest lies in identifying the evidence for these modifications and better understanding the feedbacks between life and its environment.

Martin greatly enjoys Southern California, as the hills, sea and climate remind him of his home in South Australia. The wonderful weather allows him and his wife, Eva, to pursue their hobbies of long distance running, rock climbing, tennis, and bicycling year round. Together with their sheepdog, Blue, they look forward to exploring the surrounding mountains and deserts of this beautiful region.

Adjunct Assistant Professor of Sedimentary Geochemistry and Stratigraphy

Old and New Ideas for Earthquake Prediction

by Didier Sornett

An important effort is being made worldwide in the hope that the grail of useful earthquake prediction will be attained. The research includes continuous observations of crustal movement and geodetic surveys, seismic observations, geoelectric-geomagnetic observations, and geochemical and groundwater measurements. The seismological community has been criticized in the past for promising results using various prediction techniques (e.g. dilatancy diffusion, Mogi donuts, pattern recognition algorithms, etc.) that have not delivered to the expected level. The need for a reassessment of the physical processes has been recognized and more fundamental studies are being pursued on crustal structures in seismogenic zones, historical earthquakes, active faults, laboratory fracture experiments, earthquake source processes, etc.

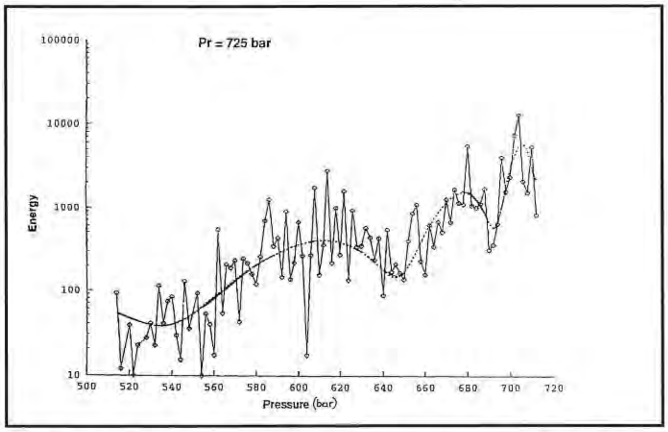


Figure 1: Instantaneous acoustic emission energy rate measured as a fiber-matrix composite pressure tank is pressurized to failure with a stress slowly increasing with a linear ramp. The data (diamonds) have been binned and are fitted to a time-to-failure power law with complex exponent represented by the dashed line.

Earthquakes occur when stress reaches a threshold and a fracture (the sudden slip of a fault) occurs in a part of the Earth's crust. The Earth's crust is complex (in composition, strength, faulting) and groundwater may play an important role. How then can one expect to unravel this complexity and achieve a useful degree of prediction?

In 1962, Mogi proposed an analogy with the rupture of brittle material and noticed that the fracture process strongly depends on the degree of heterogeneity of materials: the more heterogeneous, the more warnings one gets; the more perfect, the more treacherous is the rupture. The failure of perfect crystals is thus unpredictable while the fracture of dirty and deteriorated materials could be forecast. For once, complex systems could be simpler to apprehend! However, since its inception, this idea has not been much developed because it is hard to quantify the degrees of "useful" heterogeneity, which probably depend on other factors such as the nature of the stress field, the presence of water, etc. With J.V. Andersen from Montreal and T. Leung from Taiwan, we have recently proposed to understand this paradox quantitatively using concepts inspired from statistical physics, a domain where complexity has long been studied as resulting from collective behavior. The idea is that, upon loading a heterogeneous material, single isolated microcracks appear and then, with the increase of load or time of loading, they both grow and multiply leading to an increase of the number of cracks. As a consequence, microcracks begin to merge until a "critical density" of cracks is reached at which the main fracture is formed. It is then expected that various physical quantities (acoustic emission, elastic, transport, electric properties, etc.) will vary. However, the nature of this variation depends on the heterogeneity. The new result is that there is a threshold that can be calculated: if disorder is too small, then the precursory signals are essentially absent and prediction is impossible. In technical terms and in the language of phase transitions, the heterogeneity is a control parameter (like the temperature for the Curie point in magnetic rocks) and makes systems exhibit a so-called tri-critical transition as the disorder increases, from a Griffith-type abrupt rupture ("first-order") regime to a progressive damage ending at rupture, corresponding to a critical or "second-order" transition. The transition between the two regimes, which are two modes of brittleness culminating in a sudden failure, is different from the brittle-ductile or brittle-plastic transitions. The value of the disorder threshold separating these two regimes depends on the system strength and other properties. This has in fact been tested carefully in numerous laboratory rupture experiments (Figure 1) and forms the basis for a patent for rupture prediction based on acoustic emission (simplified scaled-down laboratory analogs of earthquakes). The idea that rupture can be "critical" is not new and was suggested in 1982 by Allegre, Le Mouel, Provost and Chelidze. The development here is the realization that that it is not always the case, why and by how much. Can this be applied to earthquakes? First, a fundamental question must be addressed: if rupture of a laboratory sample is the well-defined conclusion of the loading history, the same cannot be said for earthquakes. The problem is that it is not clear how to reconcile this idea with both the nature of the dynamical rupture propagation and the large scale and time organization of the crust, that rather suggest a succession of complex coupled irregular cycles, apparently quite different from the critical point picture. With Y. Huang, H. Saleur and C. Sammis at USC, we have recently found a way out of this conundrum by studying a simple numerical model of earthquakes on a hierarchical fault structure driven at a slow average uniform rate, taking into account the crust heterogeneity and the existence of relaxation processes. We observe that, while the system self-organizes at large time scales according to the expected statistical characteristics, such as the Gutenberg-Richter law for earthquake magnitude frequency, most of the large earthquakes have precursors occurring over time scales of tens of years and over distances of hundreds of kilometers. This type of behavior is documented in earthquake catalogs, but its interpretation leads to considerable difficulty as it is hard to understand how 1-10 km ruptures can be related over a distance of 100 km. Within the critical view point, these intermediate earthquakes are both "witnesses" and "actors" of the building-up of correlations. These precursors produce an energy release, which when measured as a time-to-failure process, is quite consistent with a power law behavior. In addition, the statistical average (over many large earthquakes) of the correlation length, measured as the maximum size of the precursors, also increases as a power law of the time to the large earthquake.

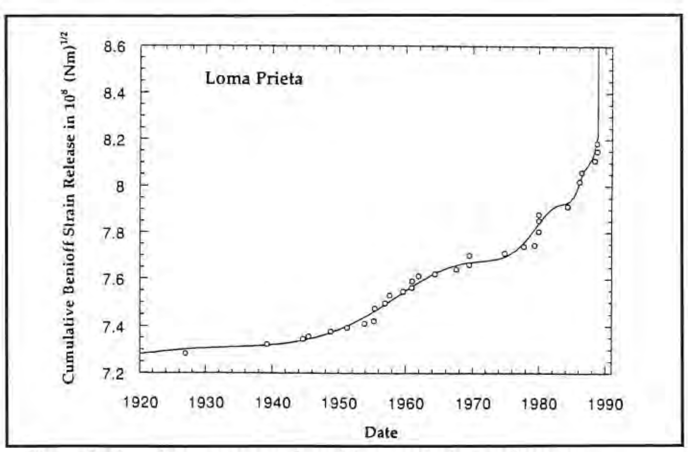


Figure 2: Cumulative energy released by magnitude 5 and greater earthquakes in the San Francisco Bay area prior to the 1989 Loma Prieta earthquake (magnitude ~6.9). The data are fitted by a time-to-failure power law with complex exponent. The same exponent (real and imaginary part) is found as in Figure 1, suggesting a "universal" behavior of the underlying rupture process.

These two properties qualify a critical behavior. From the point of view of self-organized criticality, this is surprising news: the individual large earthquakes do not lose their "identity" because they belong to the large scale and long time collective behavior of the tectonic plate. For seismologists, this is probably obvious but the critical nature is less so and remains to be proven in real data.

We must add a third and last touch to the picture. Based on theoretical considerations (mainly the renormalization group), we proposed three years ago that the critical behavior of rupture in heterogeneous materials may exhibit a behavior not seen in more familiar critical systems (such as in the Curie point of ferromagnetic materials). Due to the frozen nature of the disorder together with stress amplification effects, we predicted that the critical behavior of rupture is described by complex exponents, in other words, the measurable physical quantities can exhibit a power law behavior (real part of the exponents) decorated by log-periodic oscillations (due to the imaginary part of the exponents). Physically, this stems from a spontaneous organization on a fractal fault system with "discrete scale invariance." The practical upshot is that the log-periodic undulations may help in "synchronizing" a better fit to the data. In the above numerical model, most of the large earthquakes whose period is of the order of a century can be predicted in this way 4 years in advance with a precision better than a year. For the real earth, we do not know yet as several difficulties hinder a practical implementation, such as the definition of the relevant space-time domain. A few very suggestive fits have been done (see figure 2) but much remains to test these ideas systematically. Extreme caution should be exercised before even proposing that this method is useful for predictive purpose but the theory is beautiful in its self-consistency and, even if probably largely inaccurate, it may provide a useful guideline.

Evidence for Life on Earth by 3,850 Ma ago - 400 Ma Earlier than Previously Known

T. Mark Harrison and Kevin D. McKeegan

Scientists from the Department of Earth and Space Sciences and Scripps Institution of Oceanography have discovered evidence that pushes back the emergence of life on Earth by 400 Ma. Described in the cover story of the November 7th issue of *Nature*, the evidence comes from a rock formation on Akilia Island in southern West Greenland that is at least 3.85 Ga old. Micron-sized carbonaceous inclusions in apatite crystals were analyzed by Stephen Mojzsis, Kevin McKeegan and Mark Harrison using UCLA's new high-resolution ion microprobe. The microprobe shoots a beam of ions at a target, releasing ions from the sample which are then analyzed in a mass spectrometer. Apatite is a phosphate mineral that makes up bones and teeth and is often formed by microorganisms, but it can also be formed inorganically. The association of the carbon with the apatite is suggestive, but does not in itself establish the existence of life. The carbon isotopic abundances of these inclusions were found to be "light," favoring the ^{12}C isotope over ^{13}C. This is highly diagnostic of a biological origin as there is no known inorganic process that is able to create such isotopically light carbon. These results strongly suggest that life emerged on Earth prior to 3,850 Ma ago.

The form of life discovered was probably a simple microorganism, although its actual shape or nature cannot be ascertained because heat and pressure over time have destroyed any original physical structure. The individual samples are very small, and no instrument other than the ion microprobe would have been sensitive enough to reveal the isotopic composition and location of the carbon inclusions in the rock.

It is unknown when life first appeared on Earth. The previous earliest evidence for life was presented by Harrison's Colleague, Prof. J. William Schopf, who showed that on the basis of bacteria-like fossils, primitive life, much like modern "pond scum," existed on Earth 3.45 Ma ago.

It remains unknown when life first appeared on Earth, but the residues of ancient life that were discovered existed prior to the end of the "late heavy bombardment" of the Moon by large planetesimals, which ended approximately 3.8 Ga ago. The implication is that the assumed simultaneous bombardment of Earth did not lead to the extinction of life. This research shows that life on Earth began during the first approximately 700 million years after the formation of the planet, placing an upper limit on the time needed for the creation of life on Earth, or on the time period available for it to arrive here from elsewhere.

The CAMECA ims 1270 ion microprobe used in these analyses is the centerpiece of the W.M. Keck Foundation Center for Isotope Geochemistry. After five years of development, the ion microprobe facility is now routinely performing measurements in the U-Th-Pb systems of accessory minerals, isotopic measurements of carbon and oxygen in carbonates and silicates, and high abundance sensitivity measurements of Th isotopes in young zircons. The latter two applications are currently unique to this facility. Besides searching for evidence of early life on Earth, current research includes investigations of the evolution of the Himalayan Mountains, the environmental conditions in the early solar nebula, the evolution of porosity in sandstone petroleum reservoirs, and dating flow eruptions of hazardous volcanoes.

A Fireball Chaser's Diary

by Professor John Wasson

I don't generally chase fireballs, so I was relieved when Laurie Leshin agreed to find out whether the October 3 fireball — described by the *LA Times* as a green flash visible from Albuquerque to San Francisco — had the potential to drop recoverable meteorites. When Laurie asked what to do, Alan Rubin and I said that our usual first step was to call John Mosley at the Griffith Observatory to find out whether any of the reports mentioned sonic booms. My rule is that sonic booms are necessary, both to demonstrate that the infalling object had enough mass to provide sizable meteorites, and to indicate where they landed.

On Friday (October 4) I received a call from the *Times* science reporter, Tom Maugh. I explained that we were interested in reports of the fireball, especially if the observer had heard sonic booms, and gave him my email address. In mid-afternoon when Laurie and I consulted, the most vivid reports were from Kern County, so I called the Sheriff's office and met with immediate success. The officer at Bakersfield said that the fireball had been reported by a deputy who would call when he returned to duty. I gave Laurie the good news at Liquidus, but she was unable to follow it up because she needed to prepare for a trip to Antarctica. I agreed to take the call from the deputy, and said I would also try to get information from Inyokern on the other side of the Sierra. Somewhat mellowed by a Moosehead, I went back upstairs and within minutes was speaking with a deputy in Inyokern. He had been driving north to the Inyokern airport, but had seen the fireball, pulled over and stuck his head out the window. He reported that the fireball disappeared in the northwest at an elevation of about 70°. He stated, as did many observers, that one could see several glowing embers falling below the end of the fireball track. This put the probable location of the meteorite strewnfield in the southern Sierra.

Drawing of the meteorite as seen on October 3, 1996 by Carl Raillard of Sebastopol, CA.

Meteoroids generally enter the atmosphere at about 20 km/s. They experience enough friction to become luminescent when they drop to an altitude below 100 km, and eventually slow to terminal or free-fall velocity of roughly 0.1 km/s, less than the speed of sound. Upon reaching terminal velocity they are no longer luminescent and they fall essentially straight down, although winds may move them moderate distances away from the extrapolation of the fireball's ground track. Because sound generated above about 60 km is refracted upwards, sonic booms are only heard when the meteoroid is at lower altitudes. And most of the sound seems to be emitted in a terminal explosion that occurs when the ram pressure of the resisting atmosphere exceeds the strength of the meteoroid.

Maugh's article appeared on the front page of the Metro section of the *Times* on Saturday. On Sunday I had 15 email messages (now, nine weeks later, the number has reached about 300). One was from a seventh grader, Adam Graff, who was in Lower Peppermint Campground north of Kernville and was performing a skit when the grand celestial show occurred. He and his whole class saw the event and heard the sonic booms a couple of minutes later. They described these as sounding like an earthquake had triggered a rockslide a few canyons away. Their observations convinced me that we knew the fall location to within about 20-30 km, but that the terrain would make recovery difficult.

On Monday (October 7) I was interviewed again by Maugh and also by Jane Allen from AP. The fact that key information about the fall location had been supplied by email from a seventh-grader caught the imagination of the California news media. This time we were on page 3 of the *Times*, and on the front pages of many smaller California newspapers. Since our main goal was to find out where the object fell, we concentrated on reports of sonic booms. Some were in the area northeast of Kernville, including one camper at Kennedy Meadows who was almost directly below the final fireworks. The figure is an artist's impression of the fireworks made by someone camped farther away in the Sierra above Lone Pine. At this point I thought the fireball trajectory was largely from south to north, not west to east as it later proved to be. Perhaps I was unduly influenced by an email message from a woman in Long Beach who said that the loud sonic booms had caused her church to shake. One of the first 15 email messages had been from a person in Alamogordo, New Mexico. I answered immediately, asking for the exact time of the observations, but received no reply. Given what we know about the trajectory, it was clearly impossible that our California fireball had been seen in New Mexico. Fireballs are only luminescent below 100 km. Simple geometry showed that a fireball 100 km above us could only be seen as far away as western Arizona.

I had been planning collaborative research with Mark Boslough of Sandia Labs on the tektite-forming event that occurred in southeast Asia 760,000 years ago. As a result, Mark now found himself in the same position that I was in: he had become the scientist to whom fireball observations were sent. He called me on Tuesday (October 8) and told me that, as I had inferred, a separate fireball had been seen over New Mexico. The NM fireball had occurred at about 8:04 p.m. Mountain time, roughly 100 minutes earlier than our Los Angeles fireball. Mark also noted that this difference is about the time needed for a satellite to make one orbit of the Earth.

The idea that meteoroids could be braked by passing through the upper atmosphere and then be captured into Earth orbit has been around since the flight of Sputnik I. I realized that the Earth would rotate 10° in 100 minutes so that California would be waiting below when the satellite returned to Earth. I mentioned some of the other observations that would be required to make this a plausible interpretation of these two events. First, the NM fireball should have dimmed during the later part of its trajectory as the meteorite reentered a less-dense part of the atmosphere. Second, the heading of the two fireballs should be essentially the same. And third, the latitude range spanned during the first path should be approximately the same as that spanned on the final trajectory. Mark said that the reports were consistent with all of these conditions. In addition, there were no sonic booms associated with the NM fireball, suggesting that it never got below about 55 km, consistent with a grazing encounter. Because there was a video of the NM fireball, Mark was fairly certain that the object entered the atmosphere near Las Cruces and followed a generally ENE path before exiting over the Texas panhandle near Amarillo.

This was exciting stuff. Unfortunately, the two headings seemed to be different. When I told the story at an Institute of Geophysics and Planetary Physics lunch on October 11, I saved the bad news for the last. The heading of the New Mexican fireball was largely eastward, ours largely northward. Too bad!

But Boslough was convinced that the directions were not so different. I had emailed him my files and he pointed out that a number of trustworthy observers in the north of Los Angeles claimed that the object was heading generally east, despite the Long Beach report of shaking and booming. By the weekend I was ready to concede that our fireball was headed generally eastward, and quite possibly had the same ENE heading inferred for the NM fireball. The California public was excited about this event, and I wanted to get as many as possible involved in the search for fragments. We decided to offer a reward: $5000 for the first piece having a minimum size (4 oz). As we started to receive samples; about 20% were touted as qualifying for the reward, the other 80% were objects that the owner thought might be meteorites and often "confirmed" by conversations with experts. Unfortunately, none of the 100+ samples that Alan Rubin has examined has turned out to be a meteorite.

One way to pinpoint the fall location of a large meteorite is to look for seismic signals. A big rock (>100 kg) hitting the ground could produce a ground wave, but the sonic boom should also be recorded on nearby seismometers. I had not bothered to consult seismologists because I thought they would have contacted me or the press. After I received the report from the Kennedy meadows camper I sent an email message to the Caltech-USGS center suggesting that the fall location might have been in the Sierra, just west of Coso Junction on highway 395. Within hours Kate Hutton responded that the signal was visible on many of their seismographs. The operators had recognized it and penciled a notation "not an earthquake". Kate was eventually able to recognize the signals of two major explosions, the first and larger one was visible on 31 stations. Her computer program indicated that the signal originated at a depth of about 45 km within the Earth, but we were cleverer than the computers - we knew of a plane of symmetry that they had overlooked!

The first explosion occurred above the northwest end of Fivemile Canyon and the second somewhat farther east. An extrapolation based on these two points led to a predicted fall location near the Los Angeles aquaduct about 2 km south of the Little Lake Motel. The uncertainty in the estimate of the point of the explosion is only about 2 km, but the fall ellipse (where fragments large and small may have landed) could easily be 10 km long and 5km wide.

On October 28, Laurie Reed, Finn Ulff-Møller, my wife Gudrun and I drove to Little Lake. Although we thought it unlikely that the meteorite would have done us the favor of falling in the exposed bottom of the valley, we thought that we should check out these easily explored areas before we released this information to the anticipated hordes of treasure hunters. We found no meteorites, but otherwise had a fine trip.

Postscript:
This is a report of work in progress. My present assessment is that it is unlikely that the Californian and New Mexican fireballs had the same cause. Despite the very low probability that two random events could occur in a way that would so accurately mimic the properties of an object that went into orbit about the Earth, the following facts contradict this model. The video of the NM fireball shows that it broke up into pieces that would have been widely separated by the time they re-entered the atmosphere over Los Angeles. Because the likely entry velocity of an interplanetary object is >16 km/s (and not less than 11 km/s) whereas the orbital velocity at perigee is only 8 km/s, the NM object should have consumed >75% of the available kinetic energy. This is inconsistent with the fact that the CA fireball was much more luminous than the NM one. The former is described as making the night as light as day, whereas New Mexican witnesses state that their fireball was not bright enough to allow shadows to be recognized.

The most recent development is that the CA fireball produced clear signals in three infrasound arrays, the nearest of which is located at the Nuclear Weapons Test Site north of Las Vegas. At the AGU meeting this week, Doug ReVelle of Los Alamos National Lab reported that these signals allowed him to determine that the larger CA explosion was equivalent to 100-500 tons of TNT! If we assume that the object was moving at 20 km/s, this yields a mass of 2-10 tons! I'll leave it as an exercise for the reader to calculate the mass if the fireball entered the atmosphere with the orbital velocity of only 8 km/s.

David Paige, Associate Professor of Planetary Science, has been selected by NASA to be the principal investigator of the Mars Volatiles and Climate Surveyor (MVACS) integrated payload for the Mars Surveyor Program '98 Lander Mission. Scheduled to launch in January of 1999, the lander will spend ten months traveling to Mars, and then land in the south polar region in December 1999. While on the surface of Mars, the lander will conduct a series of scientific experiments to better determine the inventory and behavior of Martian volatiles, and to better define Mars' climatic history. Specific scientific goals include searching for subsurface ice deposits, determining the abundances of carbonate and hydrate minerals in the Martian soil, measuring the isotopic composition of carbon dioxide and water vapor in the Martian atmosphere and ices.

The MVACS integrated payload consists of a Surface Stereo Imager, a Meteorology Package, a Robotic Arm and Robotic Arm Camera, and Thermal and Evolved Gas Analyzer. These instruments are presently being developed at the Jet Propulsion Laboratory, the University of Arizona, and the Max Planck Institute for Aeronomy in Germany. After the payload is delivered to the spacecraft contractor this November, a facility will be set up at UCLA which will include a mockup of the lander with working versions of the instruments, and a Mission-Control Center to remotely operate the payload on Mars. It is expected that the lander will operate for 90 days on the surface of Mars. During this period, Prof. Paige's team will work around the clock at UCLA to command the instruments, receive and analyze the data, and disseminate the results to the scientific community and the public at large. So far, the project is on schedule and the team is looking forward to an exciting mission.

UCLA Visualization Center

The interdisciplinary Visualization Center has been upgraded and is now open. Located in the Geology building, room B707, the Center is open Monday through Friday from 9 a.m. to 6 p.m. and offers a wide variety of tools for scientific visualization, high-end graphics, model building, texture mapping, and animation.

The Center's primary focus is on post production, providing platforms and software not readily available elsewhere. Other services include high resolution scanning, image processing, color laser prints and transparencies. In addition, free classes will be offered on various topics throughout the year.

New additions to the Center include a Silicon Graphics High Impact workstation for high-end graphics using software such as Alias/Wavefront's Power Animator, and Explore; a SUN Ultra-2 Creator 3D workstation, for networking and scientific visualization; and a Media 100 non-linear video editing system for creating broadcast-quality video presentations.

Once your presentation materials are complete, you may want to use the Visualization Center Theater. The network-ready theater is ideal for groups of 30 or less and is equipped with an erasable white board, overhead color projector with video and computer inputs, a retractable screen, comfortable seating, and a pleasing room decor complete with preset dimmed lighting.

For more information about the Visualization Center or for a schedule of upcoming classes, drop by, check the website (www.vizlab.ucla.edu), or call (310) 206-2140 / (310) 206-2135. See you soon!

Update on Galileo Science

from Margaret Kivelson and Gerald Schubert

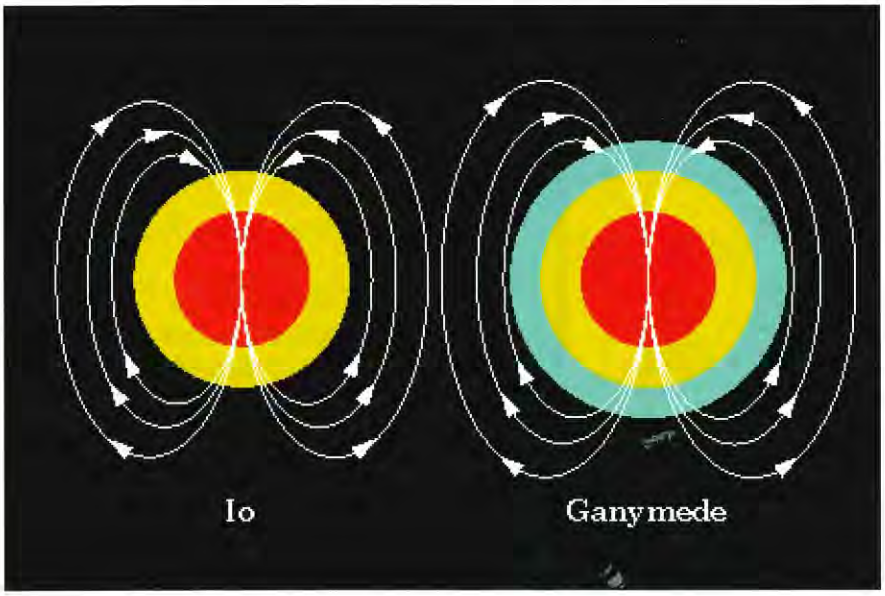
In December 1995, more than a decade after its originally anticipated arrival date, the Galileo spacecraft entered orbit around Jupiter, having first dropped a Probe into the giant planet's atmosphere. Mission objectives relate closely to interests of the ESS faculty:

- to understand the formation and evolution of Jupiter and its moons,
- to explain the dynamics of its atmosphere,
- to identify and interpret the dynamics of its immense magnetosphere.

The data already collected have brought into question many widely accepted ideas about Jupiter's atmosphere, the interiors of Jupiter's moons, the generation of magnetic fields within the moons, and the nature of the magnetospheric interactions with the moons.

High points of the new scientific discoveries include the anomalous lack of water in the clouds near Jupiter's equator through which the Probe descended. There is still controversy as to whether there really is a mechanism for removing water from the atmosphere or whether the spot through which the Probe descended was simply the Jovian equivalent of the Sahara desert. The Probe transmitted data for almost one hour until the temperature rose to about 426°K(153°C). Some believe that the entry path coincided with an intense downdraft, and that the water vapor is present at deeper levels than those at which measurements were made.

The Galileo Orbiter is now mapping out the Jovian magnetosphere measuring the properties of charged particles and the magnetic field. Patience is the watchword here, because the magnetosphere is so large that it takes months to acquire enough data to monitor its large-scale changes, but it is evident that such changes are occurring. Joint projects underway with investigators on the Hubble Space Telescope are designed to establish links between the magnetospheric dynamics and auroral activity on Jupiter.



Sketch of the interiors of Jupiter's moons Io and Ganymede as inferred from recent observations of the gravitational and magnetic fields of the satellites by the Galileo spacecraft. It has been discovered that Ganymede has a strong magnetic field and Io may also possess a magnetic field. The white lines with arrows are the magnetic field lines of the satellites. The red regions at the centers of the moons are metallic (iron and iron sulfide) cores in which the magnetic fields are generated by dynamo action. Each core can be as large as half the radius of the moon. The yellow region surrounding the core is a shell of rock and the blue region on Ganymede is an ice shell. Ganymede and Io could have similar internal structures with the exception of Ganymede's thick outer shell of water ice.

Close passes of the moons Io and Ganymede provided the most surprising of the new results. The UCLA Magnetometer measurements revealed that Ganymede (certainly) and Io (probably) have internal magnetic fields.

As the Galileo spacecraft flew by Io and Ganymede it was both accelerated and decelerated by the gravitational pull of the moons, an effect that could be detected by changes in the frequency of the radio signals from the spacecraft. Basically, the radio signals measured the gravitational fields of Io and Ganymede. Since the gravitational field of a planet or satellite depends on its internal structure, we were able to determine what the moons are like inside. It was found that Io has an iron core just like the Earth and that Ganymede has a thick (800 km) ice shell surrounding a core of rock and iron. The iron in Ganymede may be concentrated into an inner core as it is in Io. In fact, from the gravity data, Ganymede could be a body like Io surrounded by a thick ice shell. Prior to Galileo, it was not widely anticipated that Ganymede would have a magnetic field and possibly an iron core. It was also not expected that Io would have a magnetic field. However, surprises simply show us how much more we have to learn, and there is great excitement in the planetary community as it seeks an explanation of the new results.

The gravity and magnetic field observations of Io and Ganymede are complementary. The iron cores in these moons might well be the sites where the magnetic fields are created by a process known as dynamo action, the process which is also believed responsible for generating the magnetic field of our own planet.

UCLA's Department of Earth and Space Sciences is home to two of the Galileo Interdisciplinary Scientists (Professors Russell and Schubert) and one of the Principal Investigators (Professor Kivelson). We are fortunate to be so deeply involved with Galileo, one of the major space science projects of this century.

Twenty-Year Reunion Planned For Summer Field of 1977

The year 1997 will mark the 20th anniversary of the UCLA Geology Summer Field Class of 1977. It's hard to believe that two decades have passed since the movie "Star Wars" was making its debut on the big screen, Crystal Gayle was the hottest voice heard over (and over and over and over) the air waves in the Owens Valley, and Clem Nelson was leading summer field through Poleta Folds, Coyote Flat and Papoose Flat.

To celebrate the passing of time and relive past memories, a reunion of former classmates is being planned for the summer of 1997. The time and place have not yet been determined. If you are a former member of the summer field class of 1977 and are interested in joining together for memories and a good time, please contact Elizabeth (Horton) Erickson or Richard Escandon for more details. Liz can be reached at (818) 862-7776. We hope to hear from everybody. In the event that you cannot make the reunion, please call anyway so that we can hear from you and report your whereabouts to the rest of the class.

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UCLA 1996

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Send a check made payable to the *UC Regents*. Write to: UCLA, Department of Earth & Space Sciences, Field Guidebooks, Geology Building, Rm. 3806, Los Angeles, CA 90095-1567. If there are any questions, please call Professor Ray Ingersoll at (310) 825-8634.

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Class of 1996

Honors and Awards

John W. & Frances R. Handin Scholarship

Presented to undergraduates for scholastic excellence,
this award was endowed by Department alumnus
John W. Handin (BA '42, MA '48, Ph.D. '49) and his wife, Frances.

Bryan Kerr

Eugene B. Waggoner Scholarship

Awarded for academic excellence,
this scholarship honors the memory of
Department alumnus Eugene B. Waggoner (BA '38, MA '39).

Christina Engler

Alumni Scholarship

The Alumni Scholarship is awarded to students for scholastic excellence
and is supported by the alumni

Elizabeth Madsen

Sabins/Chevron Summer Field Award

Through the generosity of long-time Departmental friend
and adjunct professor, Floyd Sabins, and Chevron Oil Company, this
award is conferred for scholastic excellence to summer field students.

Jacquelyn Jones
Kristen Kawakami

Clem Nelson Summer Field Award

Conferred for scholastic excellence, this award is generously supported
by Professor Emeritus Nelson's former field students and associates.

Elizabeth Witton

DOCTOR OF PHILOSOPHY

Gerard Talton Blanchard — *Solar Wind Control of the Westward Electrojet* (Professor McPherron) *Geophysics & Space Physics*

Shangxing Gao — *Seismic Evidence for Small Mantle Convection under the Baikal Rift Zone, Siberia* (Professor Davis) *Geophysics & Space Physics*

James G. Gehling — *Taphonomy of the Terminal Proterozoic Ediacara Biota, South Australia* (Professor Runnegar) *Geology*

Gretchen M. Lindsay — *The Evolution of Large Scale Solar Wind Disturbances and the Predictability of their Geomagnetic Effects* (Professor Russell) *Geophysics and Space Physics*

Keith Mahon — *Thermochronological and Diagenetic Investigations of the Naval Petroleum Reserve at Elk Hills, California* (Professor Harrison) *Geochemistry*

Kevin J. Peterson — *Developmental Regulatory Mechanisms and the Origin and Early Evolution of the Animal Phyla* (Professor Marshall) *Geology*

Matthew R. Saltzman — *Extinction and Environmental Change, Late Cambrian, Wyoming and Utah* (Professor Runnegar) *Geology*

MASTER OF SCIENCE

Peter Andrew Craig — *Cenozoic Development of the Kuche Forland of the Tarim Basin, Xinjiang, China* (Professor Ingersoll) *Geology*

Kimberly Suzan Holland — *Protolith and Geochronology of the Hurd Peak Gneiss, East-Central Sierra Nevada, California* (Professors Reed and Reid) *Geology*

Elizabeth P. James — *(By Comprehensive Examination) Geophysics & Space Physics*

Elizabeth Ann Large — *Miocene and Pliocene Sandstone Petrofacies of the Northern Albuquerque Basin, New Mexico* (Professor Ingersoll) *Geology*

Yao Li — *(By Comprehensive Examination) Geophysics & Space Physics*

Hong Liu — *(By Comprehensive Examination) Geophysics & Space Physics*

Connie Lynn Mongold — *Provenance and Paleotectonic Implications of Upper Miocene, Pliocene, and Lower Pleistocene Sandstones of the Los Angeles and Ventura Basins, Southern California* (Professor Ingersoll) *Geology*

Xiao-xi Ni — *(By Comprehensive Examination) Geophysics & Space Physics*

Dariusz S. Orlowski — *(By Comprehensive Examination) Geophysics & Space Physics*

Ronald C. Schmidtling III — *Three-Dimensional Reconstruction of the Hydrospires of Pentremites rusticus (Echinodermata:Blastoidea)* (Professor Marshall) *Geology*

BACHELOR OF SCIENCE

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Christina L. Camors, Geology
Rebecca J. Cave, Geology
Michael A. Fiore, Jr., Geology
Kevin T. Flanagan, Earth Science/Computer Science
Elizabeth M. Frankenbush, Earth Sciences (B.A.)
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Jacquelyn L. Jones, Geology
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Laurie McElhannon, Geology
Gregory M. Park, Geology/Psychology
Michael J. Pitta, Engineering Geology
Andrew Rigor, Engineering Geology
Kevin M. Soule, Engineering Geology
Patricia L. Teston, Applied Geophysics
Kristen A. Warner, Applied Geophysics
Michael E. Winter, Geophysics & Space Physics
Elizabeth M. Witton, Engineering Geology

Alumni News

1932

Holmes O. Miller, A.B. In 1993 he flew to Anchorage and across the Bering Sea to Providencia Russia, the most easterly town in Asia. There he boarded a Russian nuclear powered ice breaker "The Yamal". The two reactors develop 250,000 HP, enough electrical power to supply a city of 10,000 people.

"About 50 miles north of Providencia we were taken ashore by helicopter to visit a chukchi village during a religious ceremony, butchering raindeer. We also visited several archeological sites.

"We headed west to Wrangle island where we saw Muskos. At Bennett Island in the New Siberian Islands they used zodiacs to approach a herd of 100 walruses on a rocky beach. There was also a polar bear on the beach." That was the first polar bear that he had ever seen. As a serious wildlife photographer Holmes was having a field day. At Bennett Island they headed north to the North Pole. By that time they were in solid ice. They came to a dead stop and had to back up and hit the ice 4 times before breaking through.

They reached the Pole on August 30th. and celebrated with champagne and a barbeque on the ice in bright sunshine at 25 degrees Farenheit.

All told Holmes traveled 6450 miles and burned 5 lbs of nuclear fuel.

Now the big question: Why does a 16,000' ice cap still exist on Greenland when the ice cap on the rest of North America melted 10,000 years ago? Surely someone has researched this and published a paper explaining it. Give Holmes a call; he'd love to know the answer.

Holmes O. Miller

1947

Robert D. Trace, M.A., retired in 1981 and spends his winters in the lower Rio Grande Valley (Edinburg) and summers at his house in Palmyra, MO. He had a quadruple bypass and a new left hip joint in '94, but is doing OK now (slight limp only). Now much of the geology that is of interest to him is in So. Texas and NE Missouri. Are there any geologists in the extreme south of Texas? If anyone is nearby and interested in looking Robert up, here is his address: Winter (Oct-May) Rte. 10, Box 143-A, Edinburg, TX. 78539, (210) 380-1529. Summer (June-Sept.) 216 W. Elm St., Palmyra, MO 63461.

1950

Arthur Mirsky, B.A., although now retired, still enjoys roughing it in field work. In the photo Arthur takes a well-deserved break from his hard-earned sampling, from beach sands in the surf, of mostly Miocene fossils (on the window sill, including sharks' teeth, stingray barbs, whale bone, turtle shell, parrot fish mouth plates) along the Gulf Coast at Venice, Florida.

Arthur Mirsky

1958

Jennifer Kerry Lovering, M.A., started her career with a job in the Australian Bureau of Mineral Resources, as well as motherhood, teaching high school science, public service promoting women's employment and the Equal Employment Opportunity positions in the public service, Melbourne City Council and the Victorian State Electricity commision. Finally, she has been using her scientific training in her present position as a quasi magistrate adjudicating the area of workers compensation in South Australia. She finds that the skills of gathering facts or evidence, analyzing and assessing this material and finally reaching a conclusion or judgement are as important in the law as they are in science. Kerry enjoys reading the *Newsletter* and hopes to get back to California one of these days.

1960

Donald Fernow, M.A., enjoys his hobby as a world traveler. The summer of '95 was spent in parts of Asia: Kazakhstan, Uzbekistan, Kyrghyzstan, Turkmenistan, Caspian Sea, Azerbaijan, & Georgia. This past summer he toured all of Central America, The Dominican Republic, Jamaica, Panama, Honduras, Belize, Guatemala, Nicaragua and the Bahamas. In February he and his daughter toured Galapagos. Along with traveling Donald keeps himself busy with securities investments and the oil and gas business.

1969

Carroll F. Knutson, Ph.D., has retired and is doing some consulting. Also, he has been elected Vice President and President Elect of the AAPG Energy Minerals Division.

1963

Harry Green, A.B., M.S. 1967, Ph.D. 1968, is now Vice Chancellor for Research at UC Riverside, while continuing his research into the mechanisms of deep earthquakes, rheology of the mantle transition zone and ultra-high pressure metamorphism.

1976

Edward F. "Skip" Stoddard, Ph.D. is now a grandfather, believe it or not. His oldest daughter, Jen, graduated from Yale and is now a 4th year medical student, married to a 1st year intern in phychiatry and had a daughter on January 2nd of this year.

Skip has been doing a good deal of field work in the Piedmont. He attended the workshop on Teaching Mineralogy that John Brady hosted at Smith College last June He also went on several field trips, one of which went through southern Vermont. It was a great trip and a terrific meeting.

1977

Robert Macdonald, M.S., retired in 1994 from the U.S. Department of the Interior. He was a geologist with Minerals Management Service in Camarillo, California. His last two publications were both proprietary "in house" publications. *Project Summary, South Outer Banks and Basins, Offshore Southern California, Hydrocarbon Resources Study and Geologic Report, 1993; Geothermal Gradient Maps of the Santa Maria Offshore and the Santa Barbara Channel Area, 1994.*

Gary Messerotes, B.S. Since July 1994 he has been living in Buenos Aires, Argentina and is on assignment with his company, EMCON, establishing a branch of his office to conduct environmental services in Argentina, Brazil, Chile & Uruguay. This is a tremendous professional and personal opportunity.

1978

Kata McCarville, B.S., is in Colorado where she has seen a lot of other ESS Alumni. She met Clare and Brian Marshall ('78) in 1992 after they saw her picture and letter in the ESS Alumni Newsletter. They have two children. Brian Marshall is (still) employed at the USGS in Denver, working on the Yucca Mountain project. Clare is hard at work finishing up editing the Encyclopedia of Geochemistry for publishers Chapman and Hall. Kata's huband, James Taylor III, continues to work in poetry and land surveying. Kata is working at the Colorado School of Mines Computing Center, and pursuing a Ph.D. in Operations Research. Occasionally she still gets to fool around on or near rocks. Last summer, Kata codirected the first-ever Science Camp at Dinosaur Ridge. Next May, she'll be running a geology raft trip for the Association of Women Geoscientists down the Colorado River through the Grand Canyon. You don't have to be a woman scientist to go on the trip.

Kata McCarville with friend, Clare Marshall, and their children.

Ted Ball is also in the Denver area. He has three children. Judy Webster is supposedly also in Denver as well. Via the internet, Kata has also been able to contact Frank Horowitz in Perth, and Karen Cullen in the UK, Bob Tucker in Houston, and Mike and Stephanie Tiffany in LA. Most of those people were in the 1978 field session (Camp Inyo/Crooked Creek research station). They had a great 10-year reunion in 1988, and their 20th should be coming up in 1998.

Dana Polacsek, a much later graduate, is here in Golden, CO too. She is both a student at CSM and employed at the USGS.

The photo is of Kata McCarville and Laura Marshall with their children, taken at the famous dinosaur tracksite in the Alameda roadcut through the Dakota Hogback just west of Denver. The darker blobs behind them are tracks of an iguanadon: just to the right is a three-toed track of a small carnivorous dinosaur. The trackways are preserved in the Cretaceous Dakota sandstone, and enhanced with charcoal. The enhancement was done by the Friends of Dinosaur Ridge. (It is supposed to be a preservationally sound technique.)

1981

"Rip" Ford, Ph.D., has been with Draper Aden engineering (Richmond, VA), as manager of the Environmental Services Division, for four years. Typical projects include aquifer tests, subsurface contaminant studies, remediation design, soil and groundwater remediation, wetland studies and permitting, endangered species assessment, and /or historic resource studies. Raising three daughters, ages 11, 8, 6 (in search of a good cattle prod). Still miss Floor 4 swing-shift parties, Glenfiddich, darts, The Roof, and (lest we forget) the richly enlightening intellectual atmosphere in which we were continually immersed. If you know what I mean - and I think you do - give me a ring sometime at (804) 270-7675. Would love to hear from you.

1982

Steven Swanson, M.S., his previous company (PG & E Resources) was bought out by another company. Steve started a new position in October '96 with Petro Hunt Corp., where he is responsible for exploration and development in the E. Texas, N. and SE Louisiana and Mississippi/Alabama areas.

1983

Leslie Ann Klinchuch, (Maiden name Sadler), B.S., married Doug Klinchuch a year after graduation from UCLA. They have two children: Matthew (9) and Amanda (5). Leslie has worked for Chevron in Bakersfield, CA, since 1985. She specialized in environmental geology and is a Registered Geologist and a Certified Hydrogeologist. She enjoys groundwater modeling and published a paper (a fate and transport modeling case study) last year in the Division of Environmental Geosciences journal (a division of AAPG).

Leslie likes reading the Alumni News section and hopes more of her UCLA classmates will keep in touch.

Leslie Ann Klinchuch

A. Roland Mora, Ph.D., has a new job with Chevron Products Company. He is an Environmental Engineer with Marketing Operations. Roland has recently moved to Chino Hills.

1985

Peter Valles, M.S., has a new job with the Internal Consultant Shell Offshore Inc. Deepwater Division. He is also happy to say that his wife just had their second baby, Hannah Kathryn on April 26, 1995. Congratulations Peter!

Jeffrey A. Johnson

JEFFREY A. JOHNSON, PH.D., has a new job with a company called ESSO REP. (He is a Geosciences manager inFrance.)

1987

ERDEM IDIZ, PH.D., after graduating from UCLA, spent 1 1/2 years doing a post-doc in Paris. Then he joined Shell and spent 3 1/2 years in Holland before a stint in Germany. He feels very fortunate to have spent over 8 years in western Europe and now has ended up in Canada. He has been with Shell Research since 1988 and plans to stay with them for another 3 to 4 years He is enjoying Canada. "It is a blend of all things good American and European and a lot of beautiful landscapes thrown in as well."

1992

DIANNE WHITE, M.S., worked for 2 years at Bechtel Corp. as an environmental consultant after she graduated. In March of 1995 she moved to Freiburg, Germany & married her "native-freiburger" the following June. Diane currently and for the past year has been in intensive German courses and is close to fluency.

1996

RON SCHMIDTLING, M.S., is currently an employee in the scientific departmnent at the J. Paul Getty Museum in Malibu (soon to be Brentwood) in a union of his art degree and his geology degree. His current project is identifying sands, clays and plaster core materials from the insides of Renaissance Bronze sculptures. "It's mainly mineralogy work, but sometimes I actually see a tiny fossil!"

He is also in the process of publishing his master's thesis on blastoids with his advisor, Charles Marshall (hopefully some time this century).

Ron Schmidtling

Ron gave a diamond ring to a psychology graduate named Emily Yut, whom he met in the CSEOL library one evening. As is customary for geologists, the engagement event had an Earthy theme- in the high Sierras, under the giant Sequoias, and right as the beautiful comet Hayukataki shined its brightest. They plan to marry in March.

Please help us find a Lost Soul

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Aitken, James '54
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Apperson, Karen
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Wall, Ms. Barrie Dayl '80
Weese-Brown, Loralee '89
Weissberg, Dr. Byron Goodspeed '64
Westbrooke, Mr. Ian Martin '79
Williams, Mr. John Scott '71
Willott, John '70
Wilson, Leovia '89
Winge, Dr. Clarence R. '71
Withrow, Mr. Gary Gould '79
Yonkman, Mr. George William '57
Yost, Dr. S. William '53
Yudovin, Ms. Susan Mary '79
Zou, Ke-Shan'90