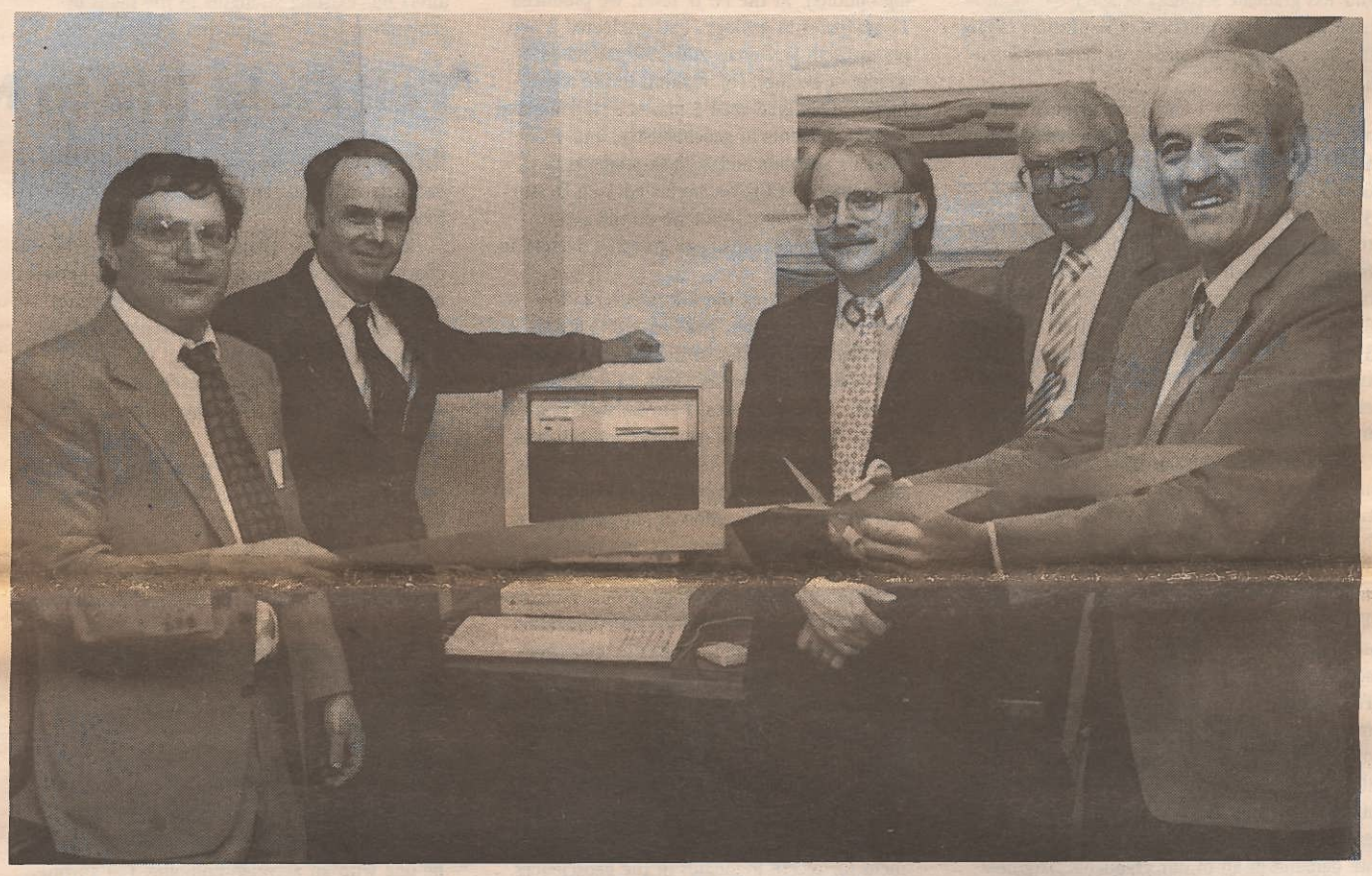
Geology News

Department of Geological Sciences ▲ University of Colorado at Boulder ▲ Summer 1992

The Energy and Minerals Applied Research Center

The Energy and Minerals Applied Research Center was established to provide a focus for our programs in petroleum and economic geology, and other applied aspects of the science. **Erle Kauffman** served as Acting Director of **EMARC** during the fall semester, 1991. The search for a new director to replace Phil Oxley was successfully completed with the appointment of **Jack Edwards**. Jack joined the faculty at the beginning of 1992. Jack has unique qualifications for the job, having served both as Chief Geologist for Exploration in Shell and as Exploration Training Manager for Shell's internal professional education programs in geology and geophysics. **Paul Weimer** is associate director. The EMARC Faculty now consists of **Bill Atkinson, Roger Bilham, David Budd, Jack Edwards, Don Eicher, Bill Hay, Erle Kauffman, Roy Kligfield, Mary Kraus, Hartmut Spetzler** and **Paul Weimer**. EMARC now serves as a home for eighteen students.

During the spring EMARC's laboratories were outfitted with state-of-the-art seismic processing and interpretation workstations and a large format color printer/plotter. Members of the department's Advisory Board participated in the ribbon-cutting ceremonies to open the new labs.



The EMARC laboratory ribbon-cutting ceremony (l. to r., Roy Kligfield, Pat Poe, Paul Weimer, Bob Graebner, and Jack Edwards). (Photo: University of Colorado)

New Lecture Series

Under the direction of Paul Weimer, an EMARC lectureship program was initiated this past year. We had four speakers in the fall and eight speakers in the spring. Three of the speakers gave one-day short courses that were available to all interested students and were well attended. We have similar plans for the 1992–1993 academic year.

EMARC guest lecturers during 1991–1992 were:

Roger Slatt (ARCO): "Applications of Gamma-ray Outcrop Logging to Reservoir Development."

Jack Edwards (Consultant): "Stratigraphic Traps."

Steve Greenlee (Exxon Production Research): "Carbonate Buildups in a Sequence Stratigraphic Framework."

John Armentrout (Mobil Research): "Biostratigraphic Applications of Sequence Stratigraphy, Gulf of Mexico" (one-day short course).

Neil Hurley (AAPG Distinguished Lecturer): "A Classic Fracture-controlled Dolomite Reservoir: Albion-Scipio Trend, Michigan."

Susan Landon (AAPG Distinguished Lecturer): "A Comparison of the East African Rift with the Midcontinent Rift of North America."

Robert Carter (AAPG Distinguished Lecturer): "Mid-Pleistocene Orbital Forcing and Continental Margin Cyclothems: Test of the Sequence Stratigraphic Model."

Jewel Wellborn and **Greg Mohl** (Conoco, Inc.): "Seismic Detection of Bright Spots, Gulf of Mexico" (one-day short course).

Michael Lewan (AAPG Distinguished Lecturer): "Understanding Generation and Expulsion of Hydrocarbons in Sedimentary Basins through Experiments."

Robert Sneider (Sneider Exploration): "Production Geology and Reservoir Needs in Field Development."

Harry Cook (AAPG Distinguished Lecturer): "Comparison of Paleozoic Passive Margin Platforms for Western United States and the Commonwealth of Independent States (former Soviet Union)."

Fred Diegel (Shell Development Co.): "Cenozoic Structural Evolution of Western Louisiana Gulf Coast: Alternative Palinspastic Reconstructions" and " Texas Gulf Coast Palinspastic Reconstruction: The Evolution of Major Structural Trends."

Ray Thomassen (Thomassen and Associates): "Current Prospect Generation in the United States."

News from the University Museum

Professor Peter Robinson reports that the Geological Section of the Museum has been busy working on computerization of the data on the fossil collections. The entire 72,000 records were finished by the end of 1991, and students and faculty now are able to quiz the database. The vertebrates were finished first, and the database on them has been used a number of times to set up research files and to answer queries.

Fieldwork in the Eocene basins of the Rockies continues, with Ph.D. student Kentaro Doi working on 800 meters of "Wasatch" and Green River section in the eastern Uinta Basin, with a fossil locality approximately every 20 meters. Peter Robinson has been working in the "Wasatch" of the Powder River Basin with good success. Other projects in the Huerfuano, Piceance Creek, and Washakie basins help to round out the collections and to establish opportunities for interbasin comparisons.

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GEOLOGY NEWS

Message from the Chair

It is always a pleasure to sit down and write a few words to you about the Department. It gives me a chance to think back over the past year, looking for the highlights (and "low-lights") to pass on to you.

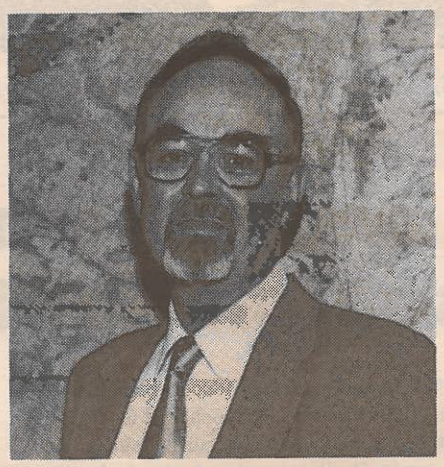
On the whole, things have gone well. Our graduate enrollment is 111 students, roughly the same as the past several years. The number of undergraduate majors continues to rise, and it stands at 86 students for the academic year 1991–1992; this represents an increase of about 40 percent over the low of 54 majors in 1989.

The graph below shows the number of student credit hours (SCH) (product of number of students times the hours of classes in geology per student) generated by the Department for the past several years. You will see that we are now teaching over 8100 SCH, which is about 75 percent of the 12,800 SCH we had in the "boom times" of 1982–83 and almost identical to the 8200 SCH in 1983–84. The difference is that we had 445 undergraduate majors and 160 graduate students in 1982–83, and 361 majors and 168 graduate students in 1983–84! We now have much larger numbers of nonmajors taking the interesting new courses we have designed for them.

Let me mention a few of the popular new courses. Representative titles are: Global Change—An Earth Science Perspective (GEOL 1060); Global Change—The Geologic Record (GEOL 3040); Mineral Resources, World Affairs, and the Environment (GEOL 3500); Environmental Issues in the Geosciences (GEOL 3520); Controversies in Planetary Geology (GEOL 3620); Evolution of Life—The Geological Record (GEOL 3720); and Natural Hazards and Geologic Catastrophes (GEOL 4950). From such titles, it will be clear to you why we have seen increased enrollments at the undergraduate, nonmajor level.

With regard to the curricula for undergraduate majors, we also have instituted some important changes in the last couple of years. Perhaps most significant, we have a new, third option, entitled "Geosciences," to go with our traditional Geology and Geophysics options. This new option allows an undergraduate student, in close consultation with a faculty advisor, to design a program that is not traditional. For example, some students may wish to work in such nontraditional fields as paleoceanography, environmental geology, and so on, and the Geosciences option will allow them to take more courses in those areas without sacrificing any of the scientific or mathematical rigor that we demand of all of our graduates. The new option still has most of the out-of-department requirements (biology may now be taken instead of physics), plus some of the traditional in-department requirements, including a course in field geology.

On a slightly different topic, I have often wondered about the numbers of students that we at CU graduate in geology compared to two other major geology departments in the State. Some statistics have recently come to me, and I thought you might find them interesting. It's a little hard to compare the schools because they give different degrees at different levels; however, the most recent figures available to me (1990–1991 academic year) show that in 1991 at the bachelor's level we graduated 12 students in geology, CSU graduated 8, and CSM 11 (the latter all in geological engineering). At



Don Runnells, departmental chair.

the master's level in 1991 we graduated 11 people, CSU 15 (5 of the latter were in the Earth Sciences option), and CSM 12 (combined numbers from geology and geological engineering options). At the Ph.D. level, we produced 14 graduates in geology, CSU graduated 2 people in Earth Resources and CSM graduated 4 people in geology. (In addition to the above figures, CSM graduated 3 master's students and 5 Ph.D. students in geochemistry, and 11 master's students and 3 Ph.D. students in geophysics.) At CU we graduated 3 Ph.D. students in Geophysics, but we do not give degrees in geochemistry or master's degrees in geophysics.

In general, from the information in the preceding paragraph, you can see that each of the major universities in the state has a strong and productive program. And, in looking at the details of the programs, I am satisfied that each school has a different emphasis and different goals for the bulk of its graduates. Of course, there is some overlap because certain topics are essential in the education of any geoscientist, such as mineralogy, petrology, field geology, and so on. However, on the whole, the schools do not duplicate each other's programs. I can also tell you that communication and cooperation between us at CU and our faculty colleagues at the other universities have never been better and are continuing to improve. We feel that the taxpayer has a right to know that we do not operate in a vacuum, oblivious to the activities and programs at other schools in the state.

Another interesting topic that has caught my attention is the changing pattern of employment for recent graduates in the geosciences. The February issue of *Geotimes* magazine (from the American Geological Institute) summarizes the figures for the hiring of new graduates at all levels in the geosciences in 1991. The figures were, by industry or institution: oil and gas—1440; mining and minerals—341; federal and state agencies—617; research institutions and DOE labs—306; environmental, hydrogeology, and geotechnical firms—2054; academia—580. Obviously the patterns of employment are changing from those that have been traditional in geology and geophysics. As you can imagine, because of the long-term nature of teaching and research, it can be very difficult for us in academic institutions to adapt to such changes.

Now, some other items concerning the Department. If you did not know, we recently lost one of our great teachers and gentlemen, Larry Warner. After a few months of fighting a variety of problems, Larry died in his sleep at home on December 20, 1991. Those of us who knew Larry loved him, and together with his family, friends, and former students, we grieve the loss. As you will see elsewhere in this newsletter, the Department has a memorial scholarship fund to honor Larry.

Prof. Ted Walker took full retirement, and Prof. Max Wyss resigned his tenured position to take a position in seismology at the University of Alaska in Fairbanks. A new addition to our tenured faculty is Prof. Bill Hay. Bill is an excellent teacher and renowned researcher in the field of marine geology and paleontology. He teaches courses in historical geology, marine geology, oceanography, and paleoclimate. Bill is also the editor of this year's newsletter.

Last, but absolutely not least, in January, 1992, we hired Dr. Jack Edwards for a non-tenured faculty position. Jack is the retired chief geologist of Shell Oil; he serves as Director of the Energy and Minerals Applied Research Center (EMARC) within our Department. As you probably recall from earlier newsletters, EMARC represents our efforts to focus and direct our existing strengths in the fields of exploration for petroleum and minerals. We always have had strong programs in these fields, and Jack will provide leadership and renewed focus in these areas. You may recall that we previously had hired Asst. Prof. Paul Weimer to replace Bruce Curtis, who had taught petroleum geology and fossil fuels for 26 years. The funds to support EMARC, including the salary of the Director, come entirely from contributions from private industry and administrative officers of the University. Although EMARC does not represent an expansion of our existing activities, it certainly does represent a focusing and rejuvenation of things that we have always done well.

That completes the things that I wanted to write. I hope that you and your families are well, and that your hopes and aspirations are being met. Please feel free to send or call your thoughts and comments to me. It would be my pleasure to serve as your host if you wish to visit the Department on your next visit to this area. Oh, by the way, we have just finished a new Departmental booklet that we send out to prospective graduate students; if you would like a copy, please let me know.

Donald D. Runnells, Chair June 5, 1992

Fall Field Trip to Nevada

Michelle Murray went on Bill Atkinson's fall field trip to Nevada and provided us with the following report:

Crack of dawn: whip-snapping and waving chocolate-covered donuts and styrofoam cups of coffee—this is how Bill Atkinson executes his strategically planned, all-too-colossal, field trips from hell. The most recent trip hosted 16 geologists with assorted levels of scientific prowess from Spain, Germany, Mexico, and the United States, and one fuzzy dog. Everyone was spiritually bound by one unifying factor, interest in The Geology of Sediment-Hosted Gold Deposits.

For anyone who has never experienced the profundity of industrial, global exploitation at its maximum, Nevada is the Mecca of devastation. "Why, even them little ladies drive those big ol' trucks and tractors the size of Kansas..." And why is this so? There are cracks in the craton in Nevada and minerals leak up there.

It's a hike or die existence following this intensely brilliant and sometimes overly adventurous professor through the bowels of boiling cauldrons and hot spring sinters into abandoned open-pit mines to feel the nature of and be one with an accreted ophiolite. Did anyone care that it was nighttime and we were 200 miles and a few hours from dinner? Of course

not. We were all thrilled for the rest of our lives. I mean that.

If you've never seen a weebalow, or eaten a huge, five-kilogram solid piece of spaghetti, or repaired a van with cardboard, you should join Professor World War Atkinson on any of his future expeditions to go where the horses are pretty, the rocks are fast, and everyone eventually speaks Spanish!

Combining Philosophy and Geology

Since Fall 1991, the Department has had a different kind of graduate student. Dr. Robert Frodeman received his Ph.D. in Philosophy from The Pennsylvania State University in 1988 and has taught at the University of Texas. He is currently enrolled in the master's program in Geology at CU. He hopes to apply his expertise in hermeneutics (the subdiscipline of philosophy concerned with processes of interpretation, whether of a library text or the "text" of the Earth's rocks) to geological problems. He is working on mass extinctions. His eventual hope is to teach interdisciplinary courses in philosophy and science.

Critical Thinking

The University has initiated "Critical Thinking" courses, of which several are taught in the Department. Jim Munoz and Bruce Jakosky have selected geologic and planetary controversies as the basis for developing students' ability to think critically about issues in science. Hartmut Spetzler has chosen to allow the students to select among societal problems that relate to Earth Sciences in the broadest sense. Hartmut comments on his experience: "I took the designation of a course as a critical thinking course to be a license to emphasize the critical thinking aspect with little regard of covering a prescribed course content (e.g., calculus could never qualify because too much material must be learned. There is simply not enough time to explore all the deep controversies that existed between Newton and Leibnitz in the development of calculus). I was mean in requiring the students to have at least one year each of university mathematics and either physics or chemistry as prerequisites. The students have diverse backgrounds, from students majoring in mathematics and engineering to those in political science and economics. They are a bright bunch.

"The class members have chosen to write a report to the Colorado Utility Commission in which they recommend the roles coal-, nuclear- and wind-generated electricity should play in Colorado's energy future. They are considering the resources, their environmental impacts, their direct health hazards, and the economics of their use. I have been very fortunate to be able to co-teach this course with Dr. Robert Frodeman, one of our master's students. Bob has a Ph.D. in Philosophy and is pursuing a master's degree in Geology to prepare himself as a unique teacher. With his input, we are tackling not only the technical and economic aspects but also ethical concerns about an energy policy and its impact on our present and future societies.

"We have visited a coal-fired power plant, a coal mine, the nuclear waste deposit site at Yucca Mountain in Nevada, and the St. Vrain nuclear power plant now being dismantled."

News from the Advisory Board

The Department's Advisory Board was established in 1985 by Hartmut Spetzler and was strengthened by John Andrews during his tenure as chair of the Department. It now consists of 15 members. Three are from the mining industry, two from universities, two from environmental consulting firms, two from governmental surveys, and six from the petroleum industry. Educational backgrounds range from the B.A. to Ph.D. Thirteen of the 15 members have at least one degree from CU. The present members are listed on the front page of this newsletter. The members serve for limited terms, so we need nominations for new members, especially from the academic world and the surveys.

The Board met October 10 and 11, 1991, and May 1, 1992. Bruce Jakosky, Alex Goetz, and Joe Smyth made presentations to the Board, describing their research programs. The meetings are exciting and characterized by a lively exchange of ideas. The new members are as enthusiastic as the continuing members. At the fall meeting, the Board discussed the educational programs with four students: Maria Montour, Sylvia Chamberlin, Marcella Hutchinson, and Ted Mowers.

The Board has encouraged the Department to develop a liberal arts pathway through geology, and to develop an option for undergraduate students to minor in geology. The result was the development of the Geosciences Option that allows undergraduates, in consultation with a faculty advisor, to design a nontraditional program.

Faculty News

John Andrews

John spent much of the summer on a research cruise off East Greenland (see page 6). He reports that he prepared for time at sea with a vacation in June 1991. He and his wife, Martha, took two old friends from England on a two-week tour of Texas, New Mexico, and Colorado. It wasn't all vacation, however, as Martha gave a paper at a meeting in San Antonio. John reports that the wild flowers along with the Texas backgrounds were outstanding.

Pete Birkeland

Pete began a year-long sabbatical trip in June. After several previous trips through the Pacific Islands, he had been trying to come up with an idea for how to stay longer on some of them. So a research plan was devised to study the soils on uplifted carbonate reefs. The presence of soils on uplifted reefs is an intriguing problem because the soils cannot be derived from weathering of the underlying materials. Possible origins are from fine-grained sediment derived from the erosion of silicate rocks elsewhere on the island, or from an eolian source such as volcanic ash of dust from the deserts of China or Australia. So, he and Sue took their bikes as field vehicles and studied and collected soils on Rota (Mariana Islands), Taiwan, Mare (Loyalty Islands), and Efate (Vanuatu). It was tough in the 100 degree heat and 200 percent humidity, but somebody had to do it. On Mare, which they rated as having the best beaches, they had to get permission to work from a tribal chief—no easy task as Pete doesn't know a word of French.

In the middle of the trip, they went to China for a meeting in Beijing, a field trip from Inner Mongolia across the Loess Plateau, and a visit to the karst terrain near Guilin. Then they traveled down the Malay Peninsula and ended up in Western Australia to see some of the lateritic terrain. The National Geographic Society sponsored the trip, and with the cheap travel and free accommodation in a Taiwan National Park, he came out right on budget. The last half of Pete's sabbatical was spent in the laboratory analyzing the soils. He hopes that John Drexler can get some numbers out of his high-powered analytical laboratory to help pinpoint the origins of the soils as well as establish trends in tropical soil development.

Pete Birkeland biking on Rota, Mariana Islands. Note the uplifted carbonate reef in the background.

Don Eicher

Don made two trips to experience different aspects of geology. Last September, he floated the Grand Canyon from Lee's Ferry to Whitmore Wash, a distance of 188 miles. Don says, "This is not such a unique experience anymore, since thousands of people do it every year, but I hadn't done it and always wanted to. For a geologist it is nearly a religious experience, and I count it as one of the highlights of recent years. September is absolutely prime time, with great temperatures and no rain."

His second trip was in March, to the Cayman Islands. The Caymans have some of the most beautiful and accessible reefs in this hemisphere. "I dived on both the Grand Cayman and Little Cayman reefs. On Little Cayman I stayed with Nancy and Ron Sefton, professional divers and naturalists. Nancy leads diving expeditions worldwide and is a world-renowned photographer of reef invertebrates. She made her extensive slide transparency collection available to me and generously donated about 150 excellent slides of invertebrates to the Department."

Mary Kraus

Mary returned to full academic duties in 1991 following a year long maternity leave and sabbatical. Together with Pete Birkeland, she has begun a new sequence of introductory geology courses for Fall Institute students. The Fall Institute is a freshman year program for students who are provisionally admitted to CU. All FI students have required courses in writing, college algebra, and a natural science. The required science courses may be either EPO Biology or Geology. In addition, the University Learning Center works with the students to develop the skills and strategies needed to complete a degree at CU.

The Department has completely revised its advising program for undergraduates. Mary has become the core advisor for the Department, primarily responsible for advising freshman and sophomore geology majors. Seven other faculty members advise on specific issues, including career opportunities, the honors program, and the new Geosciences option. In addition, Mary has become associate chair for Undergraduate Affairs.

Her research is still focused primarily on paleosols, although during the past several years she has also begun using remote sensing (down in the Center for the Study of Earth from Space, run by Alex Goetz) to study Eocene alluvial paleosols. In fact, her presentation at the Eighth Thematic Conference on Remote Sensing received the "Best of Session Award." Mary is also convening a symposium and theme session, "The Geologic Application of Paleosols," at the forthcoming GSA Annual Meeting in Cincinnati.

Paul Weimer

During the fall semester 1991, Paul taught a new course entitled "Seismic Stratigraphy and Basin Analysis." The course emphasized the integrative aspect of applied sequence stratigraphy in basin analysis. The course was taught on Tuesday and Thursday evenings and attracted 19 students, including three from the petroleum industry in Denver and four from Colorado School of Mines.

During the spring of 1992, Paul taught a section of Geology 1020 and with Jack Edwards team taught Geology 5500 Petroleum Geology.

Although he arrived only last year, he is already supervising seven graduate students, 4 Ph.D. and 3 M.S.

In August 1991, Paul participated in a research conference on High-Resolution Sequence Stratigraphy in Banff, Alberta, sponsored by the Global Sedimentary Geology Program. The program brought together all of the key workers in sequence stratigraphy. Paul served with Lee Krystinik (Union Pacific Resources) as co-organizer of one of the four main working groups, "Significance of Key Surfaces in Stratigraphy." A summary of the group's work will be published in the *AAPG Bulletin* in 1993.

During the fall, Springer-Verlag published "Sedimentary Processes of Submarine Fans and Turbidite Systems," which Paul co-edited with Martin Link of Mobil Research. During the past academic year he published two papers in the *AAPG Bulletin*, "Sequence stratigraphy of Mississippi Fan related to oxygen isotope sea level index: discussion" (September 1991) and (with Richard Buffler) "Structural geology and evolution of the Mississippi Fan foldbelt, northern deep Gulf of Mexico" (February 1992).

Paul will receive the J. C. "Cam" Sproul Memorial Award at the AAPG Annual Meeting in Calgary in June. This is the annual award that AAPG gives to the best paper written by a person 35 or younger in the *AAPG Bulletin*. The award is for Paul's paper "Sequence stratigraphy, seismic geometries, and depositional history of the Mississippi Fan, deep Gulf of Mexico" in the April 1990 *AAPG Bulletin*.

Roy Kligfield and Paul Weimer have launched an integrated research program in sequence stratigraphy and structural geology. The research is being done using seismic data primarily interpreted on a seismic workstation. They were generously given access to a 2-D and 3-D seismic data set from the Green Canyon area in the northern deep Gulf of Mexico by Halliburton Geophysical Company. Their initial research efforts will focus on the sequence stratigraphy of the turbidite systems reservoirs, and the structural reconstructions of salt movement and deep water foldbelts. They have established an industry-based consortium that is planned to run for three years. Ten companies, Union Pacific, Total, Petrobras, Shell, Chevron, Exxon, Conoco, CNG, Amoco, and Marathon, have subscribed to the consortium and there are three corporate sponsors. Seven students are conducting graduate and postgraduate research on these data. They anticipate that both the number of companies and students involved with the project will increase.

Paul is a part of the "Global Basins Research Network," a University Research Consortium coordinated by Roger Anderson of Lamont-Doherty Geological Observatory. There currently are nine universities in the consortium. One of the major efforts of the consortium is the study of heat flow and fluid movement in sedimentary basins. They have a major project in the Gulf of Mexico. Paul will be participating in this study.

Jim White

Assistant Professor Jim White and office staff member Kris Kraemer were married on July 13, 1991. Kris has worked in the Department office since October 1990 and is in charge of setting up courses, handling student inquiries, and keeping track of the graduate students. Jim joined the Department in January 1988. They have a son, Tyler James White, by Kris' previous marriage. Among other things, Jim is working on interpretation of stable isotopes in Greenland ice cores.

Kris and Jim White with son, Tyler.

1991–92 Geology Graduates

Bachelor of Arts

Jeffry B. Blake
Dennis W. Davenport
William J. Foltyn III
Mark P. Haney
Marcella M. Hutchinson
Denise R. Monroe
Jeffry S. Nichols
Michael K. Pennings
Arthur L. Smith

Master of Science Thesis Titles

Abbott, Mark
Radiocarbon Dating and Interpretation of Sediments in Five Lake Systems Along Frobisher Bay, N.W.T., Canada

Bobb, Margaret
The Calico Bed, Upper Cretaceous, Southern Utah: A Fluvial Sheet Deposit in the Western Interior Foreland Basin and Its Relationship to Eustacy and Tectonics

Greenan, David M.
Geology and Remote Sensing of the Goldstrike District, Washington County, Utah: An Integrated Study

Harding, Anne E.
Evidence of the Kane Springs Wash Caldera in the Meadow Valley Mountains, Southeastern Nevada

Howard, Avrom E.
Geology of the Wood Mountain Mine Property, Au-Ag (Telluride) Deposits, Boulder County, Colorado

Jodobdwana, Mkhuseli
Geochemistry, Ore Mineralogy, and Hydrothermal Alteration of the Cross Gold Mine

Leslie, Mark A.

Sampayo, Maria M.
Stratigraphy and Sedimentology of the Monte Grande Formation, Southwest Puerto Rico

Walker, David R.
Electromigration of Sulfate Ion through a Saturated Porous Medium

Doctor of Philosophy Dissertation Titles

Boardman, Joseph
Sedimentary Facies Analysis Using Imaging Spectrometry: A Geophysical Inverse Problem

Chen, Ganglin
Deformation of Fractures in Westerly Granite under Low Confining Stress Conditions

Diner, S. Richard
Foraminiferal Paleoecology and Paleoceanography of the Western Interior Seaway across the Cenomanian-Turonian (Cretaceous) Boundary

Hanson, David R.
Transient Creep in Natural and Synthetic, Iron-Bearing Single Crystals of Olivine

Ratliff, Robert A.
Deformation Studies of Folding and Faulting: Cross-Section Kinematics, Strain Analysis, and Three-Dimensional Geometry

Sageman, Bradley B.
High-Resolution Event Stratigraphy, Carbon Geochemistry and Paleobiology of the Upper Cenomanian Hartland Shale Member, Greenhorn Formation (Cretaceous), Western Interior, U.S.

Siders, Mary A.
Impact of the 1988 Forest Fires on the Chemistry of Ground Water in Yellowstone National Park

Slate, Janet L.
Quaternary Stratigraphy, Geomorphology and Geochronology of Alluvial Fans, Fish Lake Valley, Nevada-California

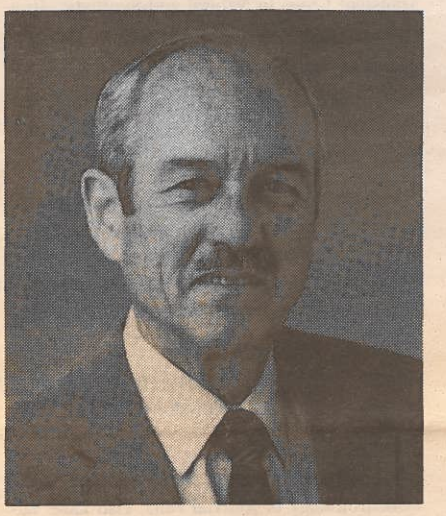
Van Dam, Tonie M.
Atmospheric Loading Response of the Solid Earth and Oceans

Zamudio, Joseph A.
A Remote Sensing and Geological Study of the Dolly Varden Mountains and Currie Hills, Nevada

New Faculty

Jack Edwards

Jack received a B.S. in Mechanical Engineering from Cornell University in 1947, attended Colorado School of Mines in 1948–9, and in 1952 obtained a Ph.D. in Geology from Columbia University. He began his geological career as a field geologist with the Unites States Geological Survey in Mexico. Stratigraphic studies of Tertiary Red conglomerates in central Mexico was the subject of his dissertation, published as USGS Professional Paper 264-H. In 1950, he joined Shell Oil Company. From then until 1962, he gained experience in field geology, photogeology and subsurface interpretation in West Texas, New Mexico, and southern Colorado. From 1962 to 1966 he worked in Shell's California region, as division exploration manager in Bakersfield and area exploration manager in Los Angeles. In 1966, after a six-month training assignment in The Hague, he was appointed chief geologist for Shell Oil Company in New York City and later assistant to the vice-president of exploration. He became exploration training manager in Houston in 1974 and in 1979 joined the Shell Oil subsidiary, Pecten International Company in Houston. His final



Jack Edwards. (Photo: University of Colorado)

position at Pecten before his retirement in 1987 was Latin American exploration operations manager. He worked principally on exploration ventures in the Brazilian Amazon and offshore. Jack is editor of *Divergent Margins Basins*, AAPG Memoir 48, published in 1990.

Jack's professional memberships include AAPG, GSA, and the Houston, Four Corners, and Rocky Mountain Geological Societies.

He is married, has five adult children and currently thirteen grandchildren. This summer he plans to take his four oldest grandsons on a raft trip down the Colorado and teach a course in structural geology at BHP in Melbourne, Australia.

Bill Hay

William W. Hay ("Bill") became a regular member of the Department with a half-time appointment on September 1, 1991. Bill has been at CU since 1982, and served as director of the University Museum from 1982 until 1987, and although he has been associated with the Department since 1982, he has only now transferred from the museum. He is currently professor of geology, fellow in the Cooperative Institute for Research in Environmental Sciences (CIRES), and associate curator in the University Museum at the University of Colorado and gastprofessor at GEOMAR, Christian-Albrechts University, Kiel, Germany. Bill spends the spring semester in Boulder and the remainder of the year at GEOMAR, the recently established Research Center for Marine Geoscience in Kiel. He also is an honorary research fellow of University College, University of London, London, U.K., and adjunct professor of Marine Geology and Geophysics at the Rosenstiel School of Marine and Atmospheric Sciences, University of Miami, Miami, FL.

Bill received a B.S. in Biology from Southern Methodist University in 1955, an M.S. in Geology from the University of Illinois in 1958, and a Ph.D. in Geology from Stanford University in 1960. He attended the University of Munich in Germany in 1953–54, the University of Zurich in Switzerland in 1955–56, and was an NSF Postdoctoral Fellow at the University of Basel, Switzerland in 1959–60.

He began his teaching career at the University of Illinois in 1960, where he became professor in 1968. In 1968 he also became professor of Marine Geology and Geophysics at the Rosenstiel School of Marine and Atmospheric Science of the University of Miami. For seven years, he spent alternate semesters at the two universities, fall in Illinois and spring in Miami. In 1974, he became chairman of the Division of Marine Geology and Geophysics in Miami. In 1976–77, he served as interim dean and from 1977–80 as dean of the Rosenstiel School of Marine and Atmospheric Science, University of Miami. From 1979–80, he served as president of Joint Oceanographic Institutions Incorporated (JOI), moving to Washington, D.C., in 1980. JOI is a consortium of Oceanographic Institutions that manages large projects funded by agencies of the U.S. government. Bill was directly concerned with the Ocean Margin Drilling Project and the inception of the ongoing Ocean Drilling Project that continues the work of the Deep Sea Drilling Project. He came to the University of Colorado in 1982, choosing Colorado as a site where one could unite interests in both marine and continental geology.

He became a permanent "gastprofessor" (visiting professor) at GEOMAR in Kiel in 1990. In 1991, he received an Alexander von Humboldt Senior Research Prize in support of work in Kiel.

His research interests started with working out the biostratigraphy of planktonic foraminifera and calcareous nannoplankton, and resulted in the development of probabilistic methods in stratigraphic correlation. The calcareous nannoplankton proved to be invaluable for dating cores recovered by the Deep Sea Drilling Project (DSDP) and led to an interest in many aspects of marine geology. More recently he has focused on geological mass balance for the global sedimentation system, modeling tectonics, erosion and sedimentation, exploring topographic and bathymetric effects on climate and oceanography, making global plate tectonic reconstructions, working on Mesozoic and Cenozoic global paleogeography, paleoclimatology, and paleoceanography.

He has been chairperson of Section E (Geology and Geography) of the American Association for the Advancement of Science (AAAS), president of both the Gulf Coast Section and national Society of Economic Paleontologists and Mineralogists (SEPM), a member of the Geological Society of America Council, and has accumulated some 46 years of service on various JOIDES (Joint Oceanographic Institutions for Deep Earth Sampling) panels and committees. He is chairman of the National Research Council Geophysics Study Committee's Panel on Pleistocene to Recent Global Geofluxes.

He is a fellow of the Geological Society of America (GSA) and Geological Society (London), a member of the American Association of Petroleum Geologists (AAPG), American Geophysical Union (AGU), Deutsche Geologische Gesellschaft, Geologische Vereinigung, International Association for Mathematical Geology, International Association of Sedimentologists, International Nannoplankton Association, National Association of Geology Teachers, Schweizerische Geologische Gesellschaft, and the Society of Economic Paleontologists and Mineralogists (SEPM). He a member of the editorial boards of newsletters on Stratigraphy and Marine Geology.

He received the Leopold von Buch Plakette from the Deutsche Geologische Gesellschaft in 1976, was elected to Omicron Delta Kappa in 1977, became a Fellow of the American Association for the Advancement of Science in 1980, was elected to Golden Key in 1980, and received SEPM's Francis P. Shepard Medal in 1981. In 1986, he was elected to membership in the oldest academy of sciences, the Deutsche Akademie der Naturforscher Leopoldina, founded in 1652 as the academy of the Holy Roman Empire.

During the spring semester, he taught an undergraduate course in Oceanography and a graduate course in Paleoclimatology. He is the editor of this year's newsletter.

He recently published "Mesozoic evolution of exotic terranes and marginal seas, western North America" (with K.M. Wilson and C.N. Wold) in T.A. Davies, A.W. Mayer and S.W. Wise (eds.), "Evolution of Mesozoic and Cenozoic Continental Margins," *Marine Geology*, 102, 311–361, 1991. Forthcoming publications include "The fit of North America, Africa and South America about the site of the future Gulf of Mexico and Caribbean" (with C.N. Wold), to appear in the *Proceedings of the VIII Congreso Espaçnola de Geologia y XII Congreso Latinoamericana de Geologia*, 22–26 June, 1992, Salamanca, Spain; "A southwest monsoon hydrographic climatology for the northwest Arabian Sea" (with J.C. Brock, C.A. McClain, and M.E. Luther), to appear in the *Journal of Geophysical Research*; "Temporal variations of the Benguela upwelling system" (with J.C. Brock), to appear in Geological Society (London) Special Publication 63, *Upwelling Systems: Evolution Since the Early Miocene*; and "The cause of the Late Cenozoic Northern Hemisphere Glaciation: A climate change enigma," to appear in *Terra Nova*.

CSES Develops Innovative New Software

The Center for the Study of Earth from Space (CSES) has developed a prototype interactive software system called the Spectral Image Processing System (SIPS) using IDl, the Interactive Data Language on UNIX-based workstations. SIPS is designed to take advantage of the combination of high spectral resolution and spatial data presentation unique to imaging spectrometers. It streamlines analysis of these data by allowing scientists to interact with entire data sets in real time. SIPS provides visualization tools for rapid exploratory analysis and numerical tools for quantitative modeling. The user interface is X-windows based, user friendly, and provides "point and click" operation. SIPS is being used for multidisciplinary research concentrating on the use of physically based analysis methods to enhance scientific results from imaging spectrometer data. The objective of this continuing effort is to develop operational techniques for quantitative analysis of imaging spectrometer data and to make them available to the scientific community prior to the launch of satellite systems such as the Earth Observing System (EOS) and the High Resolution Imaging Spectrometer (HIRIS).

Colloquium Speakers

Erle Kauffman and Joe Smyth put together a diverse, distinguished, and impressive series of colloquium speakers:

Roger Slatt, ARCO International Oil and Gas Company: "Outcrop Gamma-Ray Logging and Its Application to Reservoir Development, Exploration and Training."
(EMARC Distinguished Lecturer)

Jack Edwards, Shell Oil Company (retired): "Stratigraphic Traps."

James Cole, University of Canterbury, New Zealand: "Volcanic Hazards on the North Island of New Zealand."

Robert Hazen, Geophysical Laboratories, Washington, D.C.: "Mineralogy of the Mantle."

François Rougerie, Orstrom de Tahiti, Papeete, Tahiti: "Coral Reef Functioning and the Nutrient Paradox: A Solution by Geothermal Endo-Upwelling."

Barry Salzman, Yale University, New Haven: "Dynamics of the Late Cenozoic Glacial Ages: A Low Order Global Model."

Sean Solomon, Massachusetts Institute of Technology, Cambridge, MA: "Tectonic Contrast Between Venus and Earth: Latest Results from Magellan."

Fred Phillips, New Mexico Institute of Technology, Socorro, NM: "Cosmogenic Chlorine 36 Dating of Landforms."

Maureen Raymo, University of California, Berkeley, CA: "Late Cenozoic Evolution of Global Climate: Ice Volume and Deep Ocean Circulation."

Andrew Davis, PTI Environmental Service, Inc.: "Geochemistry and Biological Uptake of Lead from Mining and Milling Wastes."

John M. Armentrout, Mobil Oil Company: "Biostratigraphic Patterns in Sequence Stratigraphy: Correlation and Facies Analysis."

Eric J. Barron, Earth Systems Science Center, The Pennsylvania State University, State College, PA: "Tropical Climates During Warm Geologic Periods."

Robert N. Ginsburg, Rosenstiel School of Marine and Atmospheric Sciences, University of Miami, Coral Gables, FL: "Vices and Virtues of Geological Controversies. Example: Stromatolites."

Perrti Lahermo (Visiting Professor): "Environmental Geochemistry in Fennoscandia (Northern Europe)."

Jan Cislewicz, Colorado School of Mines, Golden, CO: "Mineral Resources of the Eurasian Commonwealth of Independent States (Former Soviet Union)."

Joseph R. Smyth, Department of Geological Sciences, University of Colorado at Boulder: "Hydro-Geology of the Earth's Mantle."

W. Ian Ridley, U.S. Geological Survey, Denver, CO: "Geology of a Leaky Transform: Siqueiros Fracture Zone."

Dawn Kaback, Department of Energy Savannah River Laboratory, SC: "Environmental Monitoring and Restoration at Savannah River Laboratory, South Carolina."

James Corbridge, Chancellor, University of Colorado at Boulder: "Water Rights, Laws and Wars in the Western United States."

James J. Papike, University of New Mexico, Albuquerque, NM: "The Unique Volcanic System of the Valley of Ten Thousand Smokes, Katmai, Alaska."

Troy Pewe, Arizona State University: "Cenozoic History of the Fairbanks Area, Alaska."

Jack Sepkowski, University of Chicago, Chicago, IL: "Phanerozoic Evolution of Biodiversity."

David W. Scholl, U.S. Geological Survey, Menlo Park, CA: "Deep Sea Drilling Confirms and Evaluates Non-Accretionary and Erosion Processes at Subduction Zones."

William Boberg, Exploration Consultant: "Mineral Exploration in West Africa."

Joaquin Ruiz, University of Arizona: "Precambrian Geology of Mexico."

D. Kirk Nordstrom, U.S. Geological Survey, Denver, CO: "Environmental Effects and Mitigation of Extremely Acidic Mine Waters at Iron Mountain, California."

Jeffry Abbott, Homestake Mining Corporation, Golden, CO: "Ore Deposits and Exploration in Chile."

John Wahr, Department of Physics, University of Colorado at Boulder: "Lateral Structure of the Deep Earth."

Awards to Students

Senior **Gary Fager** was selected as the department's outstanding senior to receive the Brunton Compass and a Johnston Scholarship Award in the amount of $360 in recognition of his superb record. He also received the Rocky Mountain Association of Geologists' Neal J. Harr Memorial Outstanding Student Award, an engraved, leather-handled Estwing pick. In addition Gary received the Steve Champlin Award in the amount of $1,000 from the Wyoming Geological Association. Gary says that he has acquired other rock picks in his career, but the RMAG award is the first one with a leather handle. Alas, the beautiful engraving on the blade discourages its use in the field.

Gary is interested in structural geology and considers himself an old-fashioned field geologist who prefers tramping in search of the crucial outcrop to hunching over a computer.

Jeffry B. Blake received the department's Estwing Pick Award to an outstanding senior.

Mark D. Williams received the department's Estwing Pick as an outstanding junior.

Robyn Habegger and **Thomas Cooper** both received Johnston Scholarship Awards in the amounts of $360 in recognition of their records as outstanding seniors.

Bill Little received the Keith Marks Scholarship in the amount of $394.

Robert Ratliff and **Tomas Villamil** each received Longley-Wahlstrom-Warner Scholarships in the amount of $610.

Interest income from the scholarship funds is used each year to provide the departmental awards.

The Association of Women Geoscientists honored **Robyn Habegger** as outstanding B.A., **Maria Montour** as outstanding M.S., and **Mary Siders** *as outstanding Ph.D.*

The following graduate students submitted proposals for the projects listed. They each received $500 funding to assist them with their 1992 summer research. Fifty percent of this funding came from alumni gifts and fifty percent from the Shell Foundation.

Aslan, Andres: Floodplain Deposition, Soil Formation, and Shallow-Burial Diagenesis in the Lower Mississippi River Valley

Bahr, David: Verification of Glacial Velocity Perturbation Analysis

Barlow, Lisa: Deuterium and Deuterium Excess in the Greenland Ice Sheet Project II Ice Core, Summit, Greenland

Baugh, William: Quantitative Geochemical Mapping of Ammonium Minerals Using Field and Airborne Spectrometers, Cedar Mountains, Esmerelda County, Nevada

Bennett, Scott: Santa Teresa District, Sonora, Mexico: Gold Exploration by use of Lithologic Mapping, Remote Sensing, and Geographical Information System Analysis

Campbell, Lisa: An Nd Isotopic Study of the Tectonic Assembly of the Labrador Segment of the Canadian Shield

Cherry, Randall: Attenuation of Seismic Waves in Sedimentary Rocks as a Function of Frequency, Pressure, Temperature and Fluid Content

DeConto, Robert: Mass-age Distribution of Cenozoic and Mesozoic Sediment in the Western North Atlantic Ocean

Duvall, Mathieu: The Late-Foxe Glacial Geology of the Mid-Frobisher Bay Region, Baffin Island, N.W.T., Canada

Harries, Peter: Patterns of Survival and Recovery Following the Cenomanian-Turonian (Mid-Cretaceous) Mass Extinction

Hasiotis, Steven: Partitioning of Scoyenia Ichnofacies: A Model Synthesized from Ichnofossil-Bearing Mesozoic and Cenozoic Terrestrial Deposits: A Model Developed from the Upper Cretaceous Castlegate Sandstone of Northeastern Utah

Herzog, John: The Importance of Thermocline Doming to the Development of Open Ocean Upwelling in the Eastern Tropical Atlantic Ocean

Hiatt, Eric: Paleoceanography of the Permian Paleoshelf, West Central Wyoming: A Coupled Chemostratigraphic and Sequence Stratigraphic Approach

Hughen, Konrad: Baffin Island Lake Core Study

Jackson, Michael: Determining the Present Style of Deformation in Central Afar, Ethiopia

Jaecks, Glenn: The Biological and Ecological Effects of and on Extinction Events: A Paleoecological Study of Oligocene Patch Reefs in Puerto Rico

Johnson, Brent: Water/Rock Interaction of the Floridan Aquifer: A Detailed Analysis of Ion Fluxes and Fluid Mixing in Precipitation and Dissolution of Dolomite, Calcite and Anhydrite

Krumm, Debra: Evolution of Cretaceous to Tertiary Endolithic and Epibiont Reef Communities of the Caribbean Region

Lester, Alan: Thermal and Hydrothermal Effects Marginal to a Cretaceous Pluton in the Colorado Front Range

Liang, Belyuan: Relative Magnitude of Tectonic Stress in Space Combining with the Constraints of P-Wave Structure, Geodetic and Focal Mechanism Data

Little, William: Influence of Tectonics and Eustacy on Fluvial Architecture, Middle Coniacian through Paleocene Strata of the Kaiparowits Plateau, South-Central Utah

Lubinski, David: Late Quaternary Paleoceanographic Records from the Northeastern Barents Sea, Western Franz Josef Land Archipelago and the Franz-Victoria Trough

Manley, Bill: Past Ice-Flow Patterns and Sea-Level Changes on Southernmost Baffin Island

Mieras, Barbara: Eustatic and Tectonic Controls on Deposition and Sequence Stratigraphy, Frontier Formation, South-Central Wyoming

Miller, Raoul: Climatic Records and Geochronological Correlations from C Signal of Organic Lake Sediments from Southern Baffin Island

Morrow, Jared: Conodont Biofacies and Depositional History of the Frasnian-Famennian Mass Extinction Event, Eastern-Central Nevada

Noble, Robinson: Sequence Boundary Indicators of the Floridan Aquifer: A High-Resolution Statistical Analysis of Sequence Boundary Indicators in Core

Rosetti, Dilce: Depositional Environment of the Lower Member of the Itapecuru Formation, Sao Luis Basin, Brazil.

Santos, Hernan: The Evolution of Upper Cretaceous Carbonate Platforms and Biotas, Southwestern Puerto Rico

Sauer, Peter: Paleoclimatic Information from Sediment Cores in the Form of Pollen, Diatoms, Stable Isotopes, Plant and Animal Macrofossils, and Sedimentology.

Schutz, Martin: A Comparative Climatic and Ecological History of a Pleistocene and a Recent Coral Reef on Puerto Rico

Shippert, Peg: Temporal and Spatial Variability of Vegetation Abundance in the Sandhills of Northeastern Colorado

Toledo, Peter: Locomotory Patterns of the Pleistocene Sloths

Vaugh, Bruce: Stable Isotopes and Alpine Glaciers

Villamil, Tomas: High-Resolution Event Stratigraphy of the Albian to Santonian Villetal Group of Colombia and Venezuela

Whitehead, Scott: Ultrasonic Equation of State Measurements

Wong, Felicity: Seismic Absorption in Fluid-Filled Porous Rocks as a Function of Seismic Frequencies, Pressure and Temperature

Young, Kathryn: Geophysics Involving Remote Sensing of the Earth's Surface in Death Valley

Yuhas, Roberta: Landscape Response to Holocene Climate Change: Evidence from Remotely Sensed Data and Ground-Based Studies in Northeastern Colorado

Summer funding for graduate students has always been very important for their research. We regret that we have received notice that the Shell Foundation funding for this program will be discontinued in the future. We will continue the program to the extent possible with funding from gifts to the department.

What's New in the Earth Sciences Library

—Suzanne Larsen

The Earth Sciences Library continues to make great progress in providing state-of-the-art information access to the Department of Geological Sciences. Over the past few years, we have added subsidized online searching for the Department and several CD-ROM databases, such as GEOREF (which is the Bibliography and Index of Geology and mirrors the online GEOREF file) and Selected Water Resources Abstracts. The CD-ROM databases are menu-driven and allow end-user searching. They are available any time the Earth Sciences Library is open. Use of these databases is not restricted to University affiliates; they are open to the general public as well.

A second CD-ROM workstation was added last year to meet the increased demand for access to those databases. The drawback, even with two stations, was that use was limited to one user per disc. This spring, a local area network (LAN) is being installed that will link the two CD-ROM workstations and the PC in the Librarian's office together. The CD-ROM discs will be placed in a multi-disc server driven by software that allows up to eight users to search the same disc at the same time. The second step, which will be completed at a later date, will allow remote access through Ethernet. This will enable faculty and students to search the databases from their offices through the University's computer network.

This entire project would not have been possible without the generous support of the Crail-Johnson Foundation (Eric C. Johnson, BA in Geology 1982 is president). Since 1988, funding from the Crail-Johnson Foundation has been used to purchase back issues of journals, to buy computer equipment, and to supplement the book budget to the point that we now have one of the best collections in the region. The gift was given in memory of Jerry Crail Johnson, the first woman to graduate in the field of geology from Northwestern University and an ardent supporter of libraries.

1991 Department Field Trip

Allison Burchell and Peg Shippert reported on the Fall Departmental Field Trip in the graduate student's newsletter, *The Geo Grad Rap*, and we reprint it here.

For all of "you who know who you are" who couldn't make this year's alumni/department picnic and field trip, you missed a good one. The University Food Service catered a great dinner, courtesy of the Alumni Association, and each of the field trip leaders did a prime job! Food, geology, good conversation, and fun was plentiful throughout the weekend. As far as we know there were no romances initiated, although Steve the Greek did his best.

On Friday afternoon, Bill Atkinson escorted us to the Caribou-Cross Gold Mine in Nederland, which is owned and operated by CU alum big Tom Hendricks and his partner. Tom taught us about the Laramide age Apache stock and about environmentally conscious mining practices. Thanks Tom!

On Saturday, Alan Lester led a superb whistle stop tour of Colorado geology. We visited Bull Lake glacial deposits near the base of Longs Peak (1.46 ga Silver Plume granite). At the Lawn Lake overlook in Rocky Mountain National Park, Alan led a discussion about the geochemical and tectonic evolution of the Colorado crust. Neither sleet nor snow stopped this troupe as Alan marched us along Tombstone Ridge at the continental divide to examine the 1.3 ga "Iron Dike" and its content with the country rock. Great job Alan!

Bill Braddock arrived on the scene Sunday morning to help us wring out our rain-soaked gear and heads. After a simply awful breakfast at the only spoon in Estes Park that would seat our motley crew at 8 in the morning (The Happy Texans), Bill led an expert tour through geologic time and metamorphic grades and structures. The highlights of Sunday's tour included 1.65-1.75 ga supercrustal metavolcanics and metasediments derived principally from the 2.2-2.5 ga Wyoming Craton to the north; the 1.73 ga Palisades Mountain Trondhjemite; the 1.7 ga Boulder Creek Granodiorite; and the 1.46 ga Silver Plume Monzonite. At Carter Lake we ate lunch on the Fountain Formation, which rests above the Great Unconformity.

The graduate students attending this event were glad to have a chance to mingle with so many geo faculty and staff at the Friday evening picnic. We would especially like to express our appreciation to those who participated in the field trips and/or Saturday night campout: Suzanne Larsen, Tami McCormick, Hartmut Spetzler, Joe Smyth. Your presence helped to make this event a more complete geology department experience.

Recent Grad Finds Dinosaur Nest

The Grand Junction *Daily Sentinel* had a front page article about one of our graduates in its February 10, 1992, issue. On June 28, 1991, Jim Kirkland, a 1990 Ph.D. who works for the Dinamation International Society, was guiding one of the summer interns on a tour of the Fruita Paleontological Area. He noticed a group of small dinosaur fossils and fragments of what turned out to be eggshell. He also found crocodile skeletons nearby. Jim had discovered the third nesting site of Jurassic dinosaurs to be found in the world; the other two sites are also in western Colorado. The nesting site contained babies of dryosaurus, one specimen preserved the moment the hatchling was emerging from the egg. The crocodiles were probably egg thieves, hunting for the eggs and young dinosaurs.

Jim has a remarkable eye for discovering fossils. In 1981, he helped with the excavation of the oldest mammal found in the western hemisphere. In 1983, he discovered the oldest marsupial. He has discovered five new species of dinosaur. Robert Bakker says, "Jim is an amazing guy. Finding dinosaurs is strange—you have to have a special sense to do it."

The Dinamation International Society, for which Jim works as paleontologist, is a nonprofit organization established by Dinamation International Corporation, makers of robotic dinosaurs, to foster research on dinosaurs.

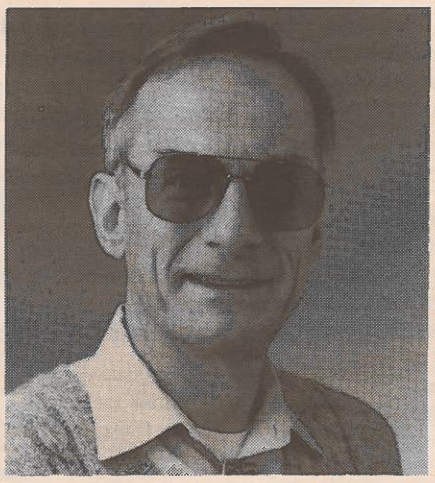
Teaching Geophysics to Nonscientists

Hartmut Spetzler and Roger Bilham team-teach "The Dynamic Earth," a course in geophysicists for nonscience majors. The enrollment is typically 160 or more and the course is offered both semesters. Hartmut describes how to entice students into finding geophysics to be fun:

"I always invent new approaches and homework problems. During the last two years, I have given the students Meyer-Briggs type indicator tests. These are tests one cannot flunk, but give the students insight into how they approach life in general and their studies in particular. Some of the students benefit from it greatly and use it in their interaction with others. To accommodate the students, different approaches to learning, I prepare three different tests for each exam and let them choose which one they wish to take. Most of the questions require an essay answer, requiring complete and coherent sentences. The students are not always happy about that, but in general they appreciate my efforts and agree that they need to learn to write. And what better subject to write about than geology!

"Computer grading, used in most large courses today, would be very economical in terms of my time, but is out of the question with the type of exam we use." Hartmut and Roger and their graduate teaching assistant read and correct hundreds of essay questions each semester. It's difficult, time-consuming, old-fashioned, and very effective. For many students it is their first experience in personal attention and interaction with faculty in their college experience. Hartmut continues, "You can see why we only last one-half semester at a time. I have been fortunate with my teaching assistants over the years. They have put forth an inordinate effort with many extra hours in grading to support my teaching method. Robert DeConto, a graduate student working with Bill Hay, has assisted me during this last year with great enthusiasm and compassion for the students.

"The students in Dynamic Earth are mostly nonscience majors and often have difficulties with scientific concepts. I consider a basic



Hartmut Spetzler. (Photo: University of Colorado)

understanding of energy and power essential if one wishes to understand the world about us. Thus the following homework problem from last fall:

The Energy (Homework) Problem

"The 'Energy Crisis' is a ubiquitous one, and not in the least in our understanding of energy. It is the function of this homework to gain a real understanding of energy and the rate of using or changing it, namely 'power.' An understanding of energy will help us throughout this course:

"As gravitational energy is converted to heat energy, which in turn triggers the release of nuclear energy in the interior of stars; as gravitational and nuclear energy within Earth are converted to heat energy which drives a heat engine, causing volcanic eruptions and the movement of continents; as the motion in the Earth's crust is inhibited and the energy in plate motion is stored in the form of elastic energy and subsequently released dynamically in earthquakes.

"Here is your homework problem:
A) Using the cost of electricity for which we pay approximately $0.08/kW hr (kilo Watt Hour), do $0.01 worth of mechanical work. Describe
1) how you did this work
2) how you determined how much you had to do
3) how long it took you to do it
4) what was the average power level at which you did this work
5) how you felt while you did the physical work and when you were finished.

"B) Consider the human body and the efficiency with which it converts food energy to mechanical energy, and calculate the price of food you would have to consume to generate $1.00 worth of electricity on an exercise bicycle. (You may assume that the exercise bicycle is connected to an electric generator and is 100 percent efficient in converting mechanical energy into electrical energy.) Be reasonable in the food you choose! Consider the possibility of having to generate the $1.00 worth of energy.

"C) Determine the quantities of three different fuel sources which could be consumed to generate $1.00 worth of mechanical energy. Examples of fuel sources are: solar, geothermal, coal, natural gas, gasoline, nuclear, buffalo chips, wood. Describe the environmental impact you would expect from the three fuel sources you selected.

"D) Consider some aspect of our use or misuse of energy and write an energy bill. You should assume you are an elected representative and are submitting your bill to the legislature at either the state of federal level.

"To get full credit you must do A) and one of either B) or C) or D). I will be happy to discuss any or all sections with you, even if you do more than the required. Please restrict part A) to one page and keep the other section, or sections if you wish, to no more than two pages each.

"Some hints: Should you choose to go (walk, run, bicycle, etc.) up Flagstaff, you will find a topographic map in a display case in the parking lot. It will help you to determine the altitude difference between your starting and finishing points. Should you not know how to read a topographic map by now, it is high time that you learn. Ask someone (including me) to explain it to you. Doing this homework may require you to seek some information from the library and/or the supermarket (labels on food products). Here, too, ask for help! We will be happy to help you in formulating the questions which you need to have answered by your search. Only after we have evidence of an intense library search will we provide you with the required data. Have fun doing it! Here are some units of energy and power which might be helpful.

Energy:

1 cal (calorie) = 4.184 J (Joules)

1 kcal (1 food calorie) = 1000 cal = 4 BTU (British Thermal Unit)

1 Therm = 10^5 BTU

1 W s (Watt second) = 1 J (Joule)

1 kW hr (kilo Watt hour = 3,600,000 J

1 hp s (horsepower second) = 550 ft lb (foot pound)

1 ev (electron volt) = $1.602*10^{-19}$ J

Power:

1 W (Watt) = 1 J/s (Joule per second)

1 hp (horsepower) = 746 W = 550 (ft lb)/s (foot pounds per second)

Energy Content of Fuels:

Wood .. (3 to 8)*10^3 BTU/lb

Coal (Peat to Anthracite).. (7.5 to 16)*10^3 BTU/lb

Petroleum.. (18 to 21)*10^3 BTU/lb

Ethyl alcohol (C_2H_5OH).. 13*10^3 BTU/lb

Propane (C_3H_8).. 21*10^3 BTU/lb

Butane (C_4H_{12}).. 24*10^3 BTU/lb

Hydrogen (H_2).. 61*10^3 BTU/lb or 340 BTU/ft_3

Natural Gas (90% Methane CH_4).. 20 to 24*10^3 BTU/lb or 900 to 1100 BTU/ft^3

U235 fission.. 35*10^9 BTU/lb or 1.6*10^{-12} Joules/atom

Hydrogen fusion (D^2 & H^1).. 75*10^9 BTU/lb

Sun's radiation.. 1 kW/m^2

Geothermal heatflow (avg.).. 60 mW/m^2 (0.060 W/m^2)

Research in East Greenland and the Denmark Strait

One of the key areas in the world ocean system is the narrows between Iceland and East Greenland, the Denmark Strait. It is here that large volumes of water from the Arctic Basin, exiting via Fram Strait, are added to the North Atlantic. Changes in the volume and salinity of this water can have significant effects on the production of North Atlantic Bottom Water (NABW). Some recent theories of climatic change have emphasized the role of NABW in global climate.

In late September/October, professor John Andrews was chief scientist on an international research cruise to Denmark Strait and the East Greenland shelf and fjords, between about 66 degrees and 68 degrees N latitude. Funding for the cruise came from the U.S. National Science Foundation and the Office of Naval Research. The ship we used was the Icelandic research vessel RS Bjarni Saemundsson. The scientific crew consisted of individuals from Iceland, Denmark, Germany, and from Woods Hole Oceanographic Institute and the University of Colorado in the U.S.

"The ship was 55 m in length and manned by an Icelandic crew that gave superb support to our research efforts. Food was good and plentiful, with my only problem being the occasional appearance at lunch or dinner of a particularly disgusting kind of rotten fish, an Icelandic delicacy. After never being sea-sick before, I have to admit that this dish did me in (apologies to our Icelandic graduates)!

"We were fortunate to have an exceptionally good ice year, meaning we had little ice. This allowed us to undertake surveys of parts of the shelf and fjords that normally were not accessible. Our cruise covered some 2500 nautical miles, of which about 1500 nm was directly associated with our survey of the East Greenland continental margin. Not only was it a good ice year, but also the weather on the East Greenland side was frequently calm and sunny. This contrasted with gale force winds on two occasions closer to Iceland. During various times on the cruise, we would be towing airgun and/or a high-resolution deep-towed seismic system (Huntec). We were particularly interested in the thickness and seismic stratigraphy of the Quaternary shelf and fjord sediments, which reached to a thickness of 500 m or more in places. At selected stations, we would lower a CTD system which continuously measured water temperature, salinity, sound velocity, and density, and at most stations we also would collect samples from the seafloor for examination of grain size, mineralogy, and flora and fauna. A gravity corer was employed at 15 stations where we obtained samples of the uppermost sediment between 0.2 and 2.8 m in length.

"The East Greenland fjords are spectacular. Kangerdlugssuaq is a major outlet for the East Greenland Ice Sheet and each year about 17 km^3 of ice calves into the fjord. Summits reach 2 km in elevation. Geologically the area is fascinating (although we never got ashore) as it is part of the Tertiary basaltic province. In addition, we were close to the Skaergaard intrusion, one of the classic areas for igneous petrology.

"We finally fled the North Atlantic on October 4th as we docked in the face of a force 12 gale. Flying home was no less traumatic as a tornado watch badly affected traffic into Chicago—where I spent seven hours in much greater discomfort than at any time on the cruise!

"The cores arrived in Boulder and I and two Ph.D. graduates from the Department, Anne Jennings (1989) and Kerstin Williams (1988), will be working on the sediments and physical oceanography over the next year. We hope to have another cruise to the region in October, 1992."

Using Stable Isotopes to Infer Climate Change—On Mars

Measurement of the relative abundances of stable isotopes in samples such as deep ice cores is an often-used technique to infer the changes in the climate of Earth. Recently Bruce Jakosky (assistant professor of Geology) has been using these same concepts to infer the long-term changes in the climate and volatile inventory on Mars. While terrestrial measurements rely on variations of the ratios as a function, for instance, of depth within an ice core to infer variations of climate with time, the Mars analysis relies on bulk measurements of the surface and atmosphere to infer the planet-average evolution of the water and carbon dioxide.

On Mars, measurements are available of the ratios of $^{18}O/^{16}O$ in atmospheric CO_2 and H_2O, of $^{13}C/^{12}C$ in atmospheric CO_2 and of D/H in atmospheric H_2O. In addition, these same ratios can be measured in various components of the SNC meteorites, which are thought to be pieces of the Martian surface that were ejected by large impact between about 130 and 1300 million years ago. D/H in the Mars atmosphere is enhanced by a factor of about 5 relative to water on Earth, suggesting a significant fractionation. On the other hand, $^{18}O/^{16}O$ in CO_2 is the same as terrestrial, but is 10 percent lower in H_2O.

These observations can be compared with the variations expected from processes that can fractionate the different isotopes—thermal escape into space, non-thermal escape to space, formation of carbonate mineral deposits from atmospheric CO_2, and condensation of CO_2 or H_2O ice from the atmosphere. The first two processes operate on Mars but are not significant on the Earth. While no scenarios for atmospheric evolution can be absolutely and uniquely ruled out, a strongly favored scenario does exist. In this model, fractionation of oxygen by escape to space is diluted by the exchange of atmospheric oxygen with a non-atmospheric reservoir; it is unlikely that there is sufficient CO_2 adsorbed in the regolith to serve this function, so the polar water-ice deposits must be exchanging with the atmosphere over geologic time. Exchange of oxygen between atmospheric CO_2 and H_2O probably provides the observed fractionation between those species. While the observed fractionation of D/H suggests a significant loss of water to space, the time scale on which this loss occurred is uncertain; the results can be reconciled with the oxygen results by invoking time-dependent models (which are consistent with what we know about Mars' climate).

Ongoing analysis involves trying to incorporate the recent measurements of ^{17}O in water from the SNC meteorites into the models. In addition, previous assumptions about the relative efficiency of escape of each species are being readdressed.

Ultimately, better data are required. Measurements of the isotopic abundances at the surface to an accuracy perhaps ten times that of the current measurements will allow us to distinguish between the various scenarios. Participation in the planning of future missions to Mars, and of the measurements that would be made on them, is therefore an important part of the ongoing research.

GEOLOGY NEWS

Alumni News

1953

Gail Van Hine Young (B.A., CU, '53) writes, "George and I retired last spring, bought a 22 ft. fifth wheel and headed for Anchorage, Alaska, where two of our daughters and a grandson live. The most amazing of all our adventures occurred in an Anchorage grocery store. I was wearing the "Colorado Geology" sweatshirt I'd bought at a Department reunion several years ago. A pleasant young woman, looking very surprised, stopped me and asked where I'd gotten my shirt. She said, "My husband did the design for those!' She introduced herself as **Jill Schneider** (M.A., '80). She and her husband, **Bruce Gamble** (M.A., '79), are with the U.S.G.S. in Anchorage. We decided the world really is pretty small."

Bill Siapno (B.S., Geology, Virginia Polytechnic Institute; M.S., CU, '53) is a marine science consultant in Ordinary, Virginia. He writes that he worked on the Departmental Newsletter way back in 1951-52. Recently he has worked on gold placer deposits off Alaska. He was a guest lecturer in Vladivostok in September, 1991.

1954

John Pardee (B.S., Syracuse, 1951; M.S. CU, 1954) is a consulting geologist living in Salt Lake City, Utah. He spent part of 1991 in Australia prospecting for gold.

1957

Bradford B. VanDiver (B.A., CU, 1957; M.S., CU, 1958; Ph.D., University of Washington, 1964) received a Ph.D. from the University of Washington in Seattle in 1964. He retired in 1989, built a house near the Adirondacks on the Raquette River, and writes popular books, including the *Roadside Geology of New York*, *Roadside Geology of Vermont and New Hampshire*, *Roadside Geology of Pennsylvania*, *Imprints of Time: The Art of Geology*, *Rocks and Routes of the North Country, N.Y.*, and the *Upstate New York Geology Field Guide*.

He writes that he and his wife, Bev, do lots of climbing, backpacking, canoeing, cross-country skiing. They have recently traveled to China, the U.S.S.R., Kenya, Peru, Nepal, and New Zealand. They have two sons: Thor is a M.D. intern in Boston, and Kent is a Ph.D. candidate in computer science at SUNY Albany.

1959

Richard C. Hepworth (B.A., Geology, CU, '59; M.S., Geological and Civil Engineering, University of Utah, '63) lives in Parker, Colorado, and is a self-employed consulting geotechnical engineer. He has been involved in geological engineering aspects of a number of projects in the Denver area.

Claud H. Baker, Jr. (B.A., CU, '59), has completed 30 years with the U.S. Geological Survey Water Resources Division. He is with the Kansas District as a combination hydrologist and computer specialist. He and his wife **Peggy** (B.S., CU, '56), literally built their own home. Son Peter Fritz Baker earned a Ph.D. in mathematics from Berkeley in 1988 and daughter Elizabeth Blair Baker Naime is working on an M.A. in linguistics at Kansas University.

1961

Warren Yeend (B.S., Geology, Washington State University; M.S, Geology, CU, '61; Ph.D., Geology, University of Wisconsin '65) is a geologist with the U.S. Geological Survey in Menlo Park, California. He works on placer gold deposits in Alaska.

1962

John M. Cyr (B.A., CU, '62; M.S., CU, '65) now lives in Arlington, Texas.

1973

Richard L. White (B.A., CU, '73) is exploring for uranium for the Cotter Corporation of Nucla, Colorado.

1974

Lee C. Wilson (B.A., Chemistry, Grinnell College, '70; M.S., Geology, CU, '74) is maintenance director for Snowmass Lodging Company in Snowmass Village, Colorado. He also works part time as geology instructor at Colorado Mountain College. The Wilsons have two children, a daughter, Kate, and a son, Tyler.

1976

Chip McMillan, who received four degrees from CU—a B.A. in MCDB in 1976, an M.S. in Chemistry in 1980, an M.S. in Geology in 1987, and Ph.D. in Education in 1990—teaches math and physics at Sheldon Jackson College in Sitka, Alaska. He enjoys sea kayaking, is learning to fly a bush plane, and hopes to scuba dive with killer whales.

Barbara E. Smith-Townsend (B.A., Anthropology, CU, '71; M.S., Geology, '76) is technical project manager at the Air Force Center for Environmental Excellence at Brooks Air Force Base in Texas. She supervises the investigation of past hazardous waste disposal and spill sites for the Air Force.

Jerry Bailey (B.S., Geology, University of North Dakota, '70; M.S., CU, '76) is senior development geologist with Chevron USA in Lafayette, Louisiana.

John Bradbury (B.S., Chemistry, Bucknell; M.S., Geology, CU, '76; Ph.D., Geochemistry/ Mineralogy, The Pennsylvania State University) is a geochemist for the U.S. Nuclear Regulatory Commission in Rockville, Maryland, evaluating site characterization of high-level radioactive waste repository at Yucca Mountain, Nevada. His wife, Kathy, is a reading specialist and tutor. His son, Will, is now 15 years old, interested in chaos, fractals, and astronomy. His daughter, Meg, is 12 and interested in gymnastics and marine biology.

1977

Karen Christopherson (B.A., CU, '77; M.S., CU, '79) is president of Chinook Geoconsulting, Inc., a firm that does nonseismic geophysical consulting both in the U.S. and overseas (Papua New Guinea, Australia, Africa) and provides "Geotemps"—temporary geoscience personnel. She has been married two years to Australian helicopter pilot Mike Glajnaric.

Marcia Rottman (A.B., University of California at Berkeley, 1963; Ph.D., CU, 1977) is a research associate with Exxon Production Research Co. in Houston. From February 1990 to January 1991, she worked for EPR in Jakarta, Indonesia, on seismic interpretation and managing the interpretation workstation. At EPR in Houston she is leader of a group of six specialists who support well log interpretation software. She writes, "I came home from Jakarta very sure I wanted to emphasize the computer software side rather than the geophysical and geological interpretation side of my professional life. These days I mostly manage other people's technical efforts and beat on bosses to get the group what it needs."

While in Jakarta she met Arthur Shapiro, a Canadian computer consultant. They plan to marry in 1992.

Wayne (B.A., CU, '77; M.S., Kansas, '84) and **Valerie** (B.A., CU, '79) **Premo** live in Golden, Colorado. He is geologist with the Branch of Isotope Geology of the U.S. Geological Survey in Denver. He works on U-Th-Pb, Rb-Sr, and Sm-Nd isotope systematics of ultramafic and mafic layered intrusions and lunar rocks. He married Valerie (Williams) in 1979, and they now have three children, Crystal, Ginny, and Tyler. Valerie is a pre-school aide at the Jeffco Open School.

1978

Deborah H. Schneider (B.A., CU, '78; M.S., Economic Geology, Colorado State University, '82), is project geologist with Noranda Exploration, Inc., in Lakewood, Colorado. A daughter, Claire Marie, was born July 7, 1991.

1979

Bruce C. Fuller (B.A., Psychology, New Mexico Highlands University, '67; B.A., Geology, CU '79) is project manager/geologist with Superior Environmental Co. in Grand Rapids, Michigan. He writes that his new job is a career change after 20 years in the minerals industry. He and his wife celebrated their 20th anniversary in 1990 and have two boys.

1980

Jay L. Larson (Ph.D., CU, '80) retired from the Air Force, where he served as executive officer to the director of the Defense Mapping Agency. He now works as Senior Manager—Technical for Intergraph, an earth sciences and mapping company that specializes in computer graphics. He is working on an electronic chart and display system for ships of the Woods Hole Oceanographic Institution. He reports that his son is in the Army and spent 1991 in Saudi Arabia, Kuwait, and Iraq.

1982

Janet Bronken-Jakobson (B.A., Geology, CU, '82) has moved to Trondheim, Norway, where her husband is with the Engineering University.

Kurt C. Ill (B.A., CU, '82) is laboratory director with Enseco Inc. in Houston, Texas. He works on industrial and hazardous waste analysis.

1983

Sarah C. Gray (B.A., Geology, '83) finished her Ph.D. in Earth Sciences at the University of California at Santa Cruz in 1991. She currently holds a National Research Council Post-doctoral Associateship at the Branch of Pacific Marine Geology, U.S. Geological Survey in Menlo Park, California. She is studying the record of sea-level changes preserved in reefs and atolls.

1984

Noel Ludwig (B.S., English and Geology, CU, '84) is pursuing a Ph.D. in Marine Geophysics at the University of Hawaii. He is on a four-year scholarship with the East-West Center. His research centers on relationships between porosity and seismic velocity in the upper oceanic crust. In 1991, he spent five weeks aboard the Soviet research vessel Akademik Selskiy, studying the seafloor between Christmas Island and Mexico.

David Swanson (B.A., Carleton College, '79; M.S., Geology, CU, '84; Ph.D., Soil Science, University of Minnesota, '88) married Shelli Smith in 1988. Dave is employed as a soil scientist with the USDA Soil Conservation Service in Fairbanks, Alaska. He is concerned mainly with soil mapping in the interior of Alaska. Dave recently initiated an integrated geomorphologic-soils-vegetation mapping study in the Kobuk Valley area. Shelli is a biologist for the Gates of the Arctic National Park.

1986

Dan Sedenquist (B.A., Geology, University of California at Santa Barbara, '80; M.S., CU, '86) is a technical sales manager with International Technology Corporation in San Jose, California. The firm specializes in hazardous waste site remediation and environmental engineering. His wife is a banker, and they have three children, two boys and a girl.

Nancylee Dellamonte (B.A., Geology, CU, '86) is president of Snow Motion Ski and Active Wear in New York City. She writes that she has Bill Braddock and James Cole's map on the wall of her office. She also told us that she spent several semesters working on independent study projects with John Andrews. "They were an invaluable experience and I thank him for his time and patience."

1987

Richard J. Batt (B.A., Geology, SUNY Buffalo, '79; M.S., Geology, University of Wyoming, '81; Ph.D., Geology, CU, '87; M.S., Hydrogeology, Western Michigan University, '89) taught as visiting assistant professor at Hope College in Holland, Michigan, in 1987-88 and at Western Michigan University in 1988-89. He is now assistant professor of geology in the Department of Earth Science and Science Education at Buffalo State College in Buffalo, New York. He teaches Paleontology, Stratigraphy, Hydrogeology, Physical and Historical Geology and Oceanography. He organized a two-week field trip to the Colorado Plateau for the students at Buffalo. He has published on ammonites in Palaios and Lethaia, and has a grant from the Great Lakes Center for Environmental Research to work on the hydrogeology of western New York. A daughter, Erika Lynne, was born in 1990. He reports that all the family continues to be involved in dance roller skating.

Alumni Support

The Department of Geological Sciences has several specific accounts to which contributions may be made. Checks should be made payable to the University of Colorado Foundation with a notation to which of the following funds you would like your contribution to be used for.

Scholarship Accounts:: (funds donated to these accounts are put in an interest-bearing account and the Department uses the yearly interest to provide scholarships to students).

Keith Marks Memorial Scholarship
Warren Longley Scholarship
Ernest Wahlstrom Scholarship
Larry Warner Scholarship
General Geology Scholarships

Contributions may also be made to the following accounts:

Geology General Gifts: (unrestricted funds for use at the discretion of the Chairman).

Warren O. Thompson Graduate Research: (funds are used to assist graduate students with their research).

Geology Equipment: (funds specifically designated for the purchase of equipment).

Alumni Relations: (funds specifically designated for travel, etc. to promote alumni relations).

Geological Sciences Building Fund: (funds specifically designated for the new Geological Sciences Building).

MEMORIAL

Lawrence Allen Warner

Lawrence Allen Warner, one of the most distinguished members of the department, died Friday, December 20, 1991, at his home in Boulder.

Larry Warner was born April 20, 1914, in Monroe, Ohio. He received his B.S. in Geology from Miami University of Ohio in 1937 and his Ph.D. from Johns Hopkins University in 1942, graduating Phi Beta Kappa.

In 1939 and 1940 he participated in the Third Antarctic Expedition led by Admiral Robert E. Byrd. He received the Congressional Medal for Science and Exploration in 1946.

He married Betty "Robin" Robinson on October 14, 1942, in Shaker Heights, Ohio. They moved to Boulder from Washington, D.C., in 1946. Larry was a member of the department from then until his retirement in 1981. He was awarded the University's Robert E. Stearns Award in 1964. He was always a strong supporter of the department.

He was a member of the American Association of Petroleum Geologists, The American Geophysical Union, and the Geological Society of America.

He is survived by his wife in Boulder, his son, Gary Warner of Liberty, MO, and his daughter, Susan Warner of Taos, NM.

It was suggested that those wanting to honor Larry contribute to the Longley-Wahlstrom-Warner Scholarship Fund, an important resource for support of undergraduate students.

Attention Alumni

By completing and mailing in this form, you can help us do a better job of keeping up with you and your whereabouts and career or family news. We all enjoy reading about classmates and not-so-close mates who survived Boulder in whatever era! So send us some news, or just some recollections—we promise to use it, well, most of it!

Name _____ Date _____

Address _____

Degree(s) _____
before, during, and after CU-Boulder

Current Activity/Position/Employer/Location, etc. _____

_____

_____

Publications/Awards/Accomplishments _____

_____

_____

News About Family/Kids/Friends _____

_____

_____

Name/Address of Potential CU Geology Student We Should Contact: _____

_____

Comments, Critiques, Accolades, as Appropriate, About Newsletter: _____

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Finding a Needle in Africa: A Null Result

In January 1992, Roger Bilham and graduate student Mike Jackson set off to find some 6 mm holes in lava flows somewhere in East Africa. They had been drilled by Paul Mohr (professor of Geology in Galway, Ireland) two decades ago to indicate the 1970 dimensions of the East African rift. He had measured the ≅16 km distances between the holes with a geodimeter to an accuracy of about 1 cm. Roger reports: "Our mission was to find the holes and remeasure the distances between them to see how much the African rift has widened."

Roger Bilham of University of Colorado and Paul Mohr of University of Collage, Ireland. Bilham was in Ethiopia with GPS receivers remeasuring laser and theodolite benchmarks spanning the East African rift first measured by Mohr nearly 25 years ago.

Why holes? Professor Mohr found that the usual brass or bronze pin that a surveyor would use as a survey control point would typically vanish shortly after installation to adopt an active life in the domestic equipment of a Danakil warrior or an Oromo bride. To overcome this problem he made his control points smaller. Less conspicuous bolts and nails cemented into 12 mm holes proved even more useful items in the local construction trade, and their removal by tireless small boys left messy conical holes whose original position made precise re-occupation enigmatic. Yielding to the relentless disappearance of key points over a five-year period of measurements starting in 1969, he eventually found that a 6 mm hole could not be stolen, and indeed was of little interest to the local people. To further ensure that his holes would not be stolen he decided not to publish his site descriptions: photos and step-by-step instructions of how to reach each tiny hole.

One might consider this to be the last straw, if not the last haystack. A hole, somewhere in the African rift and no description of how to reach it. The reason for this secrecy was that the last 18 years in Ethiopia have been troubled by civil war. Mohr reasoned that his holes might be considered to have been drilled for motives other than pure science. A precise historical parallel exists. It may be recalled that the British during the war destroyed the cairns laboriously erected over survey monuments in northern Iceland by Wegener's students, who believed, in 1930, that perhaps Iceland was the locus of widening in the Atlantic. The cairns were thought by the British to be aircraft navigation beacons. In fact, they covered control points whose positions had been meticulously measured using precise triangulation methods. Fortunately the British were ignorant of these subsurface marks or these too would have been erased.

We solved the problem of how to find Paul Mohr's holes by inviting him to accompany us and our satellite geodesy equipment to Ethiopia. Within a few days, he was able to locate a dozen control points. Unfortunately, the expansion of roads and villages has resulted in some points vanishing forever. We set up our GPS equipment over about five of the recovered points in the January reconnaissance survey and gathered a few million bytes of high quality p-code data for the same baselines that he measured in the 1970s. Simultaneously we made GPS measurements between each point and the distant edges of the rift, 100 km away, something not possible until recently.

It is generally believed that the current widening rate of the African rift is somewhere between 3 mm/year and 8 mm/year. Five years of uniform widening at its lowest rate would permit the spreading signal to emerge above the measurement noise of today's GPS technology. However, in order to determine widening rate and the rotation of the Somali plate relative to the rest of Africa, we needed several points on each plate. The African rift is more than 120 km wide at this point and the recovered Mohr points spanned a distance of less than 45 km. We needed more holes.

We used a portable hammer drill to make our marks. In many parts of the world (and especially in U.S. Customs), hammer drills are viewed with suspicion because they resemble machine guns. In Ethiopia, we were invisible with our hammer drill, which blended nicely with the Kalashnikoffs, bazookas and rifles carried as explosive ornaments by our African colleagues.

In addition to a GPS survey across the African Rift, we traveled to the Dobi Graben in Afar where an extraordinary series of 11 M.5 earthquakes occurred in two days in 1989. The past 18 years have left a trail of tanks and ruined bridges on the way to Dobi. We were advised to join convoys of trucks to avoid accidental crossfire of the Issas and Afars, between whom an uneasy peace exists in daylight hours. The Sultan of Afar, a man of great dignity, welcomed our visit, and extended to us the freedom of his dominions and the use of his camels for survey work. Throughout Afar we encountered happy people living in great poverty. Potable water can be obtained from geothermal wells, but only at infrequent intervals. The cost of water to our 12 person survey group was about $10/gallon as we clocked hundreds of miles of car rental in bringing it to camp. By contrast, the cost of armed guards was trivial and our camp was never without a friendly machine gun.

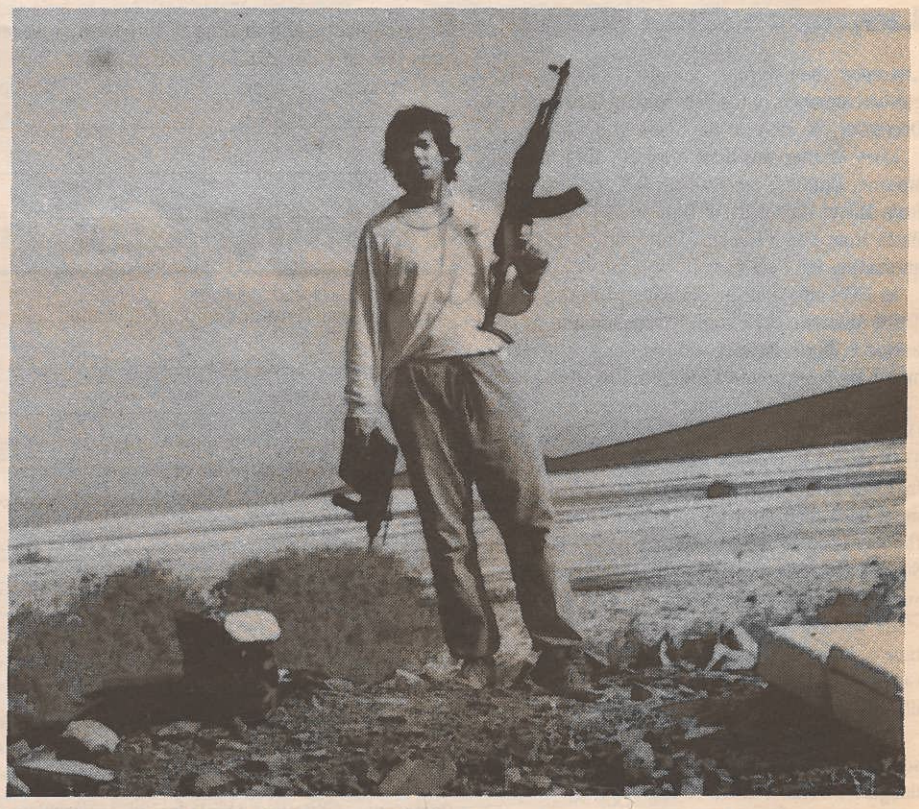
Afar field vehicle.

Afar tribesman guarding Global Positioning receiver.

A few weeks after returning to the U.S., Mike had processed our data to determine how much the African rift had widened in the past two decades. The answer? A somewhat unexpected 1–2 cm. This is a stunningly dull result. But given that the two techniques (laser trilateration and space geodesy) are associated with completely different sources of error, it is not without some interest. It is perhaps disappointing that the African rift did not take the opportunity to widen during the 18 years of the oppressive Mengistu regime in Ethiopia, but then again it is possible that we currently are witnessing a period of extensive strain that eventually will be released in a rifting episode. This is exactly what happened in Iceland. In the 1950s the Germans returned to remeasure the Iceland control points that had escaped demolition by the British to find no change. Twenty years later, however, Iceland burst apart by 8 m in a rifting episode right in the middle of the German network.

In practice, our null result represents an important upper limit for instantaneous African rift spreading rates. We measured $+1 \pm 2$ cm extension over approximately 40 percent of the rift. Were this uniformly applicable to the entire width of the rift, our data would limit rift widening rates to less than 4 mm/year for the past 20 years. But it is possible that the rift is moving in unexpected ways. One possibility proposed by Bill Hay, based on Somali/Arabian plate reconstructions, is that the rift is a transtensional feature with approximately 25 percent left lateral shear across it. We plan to return in October to measure some lines that might help constrain shear displacements in the rift. We just need to find some Mohr holes!

Roger Bilham, who traveled as a journalist with the Eritrean Liberation Front nearly 20 years ago, returns to Afar to capture footage of rift-related earthquake events.



Colorado geologist Mike Jackson puts fashion first—well dressed and well armed.