GEOLOGY & GEOPHYSICS NEWS

Yale University | Department of Geology and Geophysics Winter 2009

David Bercovici standing in one of the most recent Kline Geology Lab renovation projects. This new space consolidates an area from the back of the Library with a computer lab (which was itself formerly a hydrothermal, cold-seal pressure lab) and will become ten office spaces for postdoctoral researchers, as well as a meeting area (small conference room and reading area) for 3rd floor occupants.

Chairman's Letter

David Bercovici (david.bercovici@yale.edu)

Dear Friends of Yale Geology & Geophysics,

As I enter my third year as Geology & Geophysics Chair, I'm happy to report on continued changes and growth for our fine Department.

As you may recall, in 2007 we hired four new junior faculty members in the areas of geochemistry and geophysics. Our two geochemists, **Zhengrong Wang** and **Hagit Affek**, both started their positions in 2007. This academic year our two geophysicists arrive: Mineral physicist **Kanani Lee** started in July of 2008, and seismologist **Maureen Long** will start in January 2009. With four new junior faculty members, there will come expansion in laboratory facilities and more students and postdoctoral scholars.

This fall, geologist and paleomagician **David Evans '92,** who was the recipient of the David and Lucille Packard Award in 2002, was promoted to Professor, effective January 2009. David is a vital member of our senior faculty and he has already agreed to be the Director of Undergraduate Studies in Fall 2009.

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FACULTY RESEARCH

Clumped Isotopes

by Hagit Affek

Hagit Affek *(hagit.affek@yale.edu) joined the department in July 2007. Her research involves applications of stable isotopes to environmental questions. After a year of renovations her new laboratory is one of the few in the world that measures "clumped isotopes" as isotopic tracers. Hagit applies clumped isotopes to both paleoclimate reconstructions and the modern carbon cycle research.*

Caves and air: Isotopes and climate change

Prediction of climate changes requires detailed understandings of changes in the atmosphere and the factors that control them, plus an understanding of the response of the climate system to the changes. For example, the increase of atmospheric CO_2 due to combustion of fossil fuels is modified by CO_2 uptake and release by natural processes of the global carbon cycle, such as dissolution in the oceans, uptake by the biosphere, and release by decomposition of organic matter. Isotopic measurements of CO_2 are essential in distinguishing and quantifying these sources and sinks of CO_2.

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SAVE THE DATE!

ALUMNI REUNION AND CONFERENCE
FRIDAY–SUNDAY, NOVEMBER 6–8, 2009
Invitations will be mailed Early Spring 2009

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Unfortunately, atmospheric scientist **Steve Sherwood** is leaving us to become the Chair of Atmospheric Sciences at the Climate Change Research Center at the University of New South Wales. Steve will assume his new duties in January 2009 and we will sorely miss him. Steve was one of the outstanding authorities on climate change at Yale; he was the recipient of the Clarence Leroy Meisinger Award from the American Meteorological Society in 2005 and was one of only two Yale contributing authors to the Nobel Prize winning IPCC report of 2007. Steve was also one of the first junior faculty to arrive in the hiring initiative of 1999 to 2000, and we are proud of the work he did here while being promoted up through the ranks to Professor in 2007.

As a consequence of Steve Sherwood's departure, we have initiated a search in Atmospheric Physics and Climate Dynamics, with clearance to consider excellent senior targets. We hope to have good news on the outcome of this search in a year's time.

On a somewhat related note, the Department hosted an Ocean-Climate Symposium last April on the interplay between ocean circulation and climate variation. As a result of this symposium, we are exploring a possible offer for a faculty position to one particularly talented young scientist, whose name I can't yet divulge (just to add some mystery to this Newsletter). I hope we will be able to report good news on this development in the next Newsletter.

With the continued expansion of the Department, and through the tireless efforts of our Director of Graduate Studies, **John Wettlaufer**, this last year was a truly banner year with graduate student enrollments. In normal years we typically matriculate between 7 and 11 students. However, in 2008, 19 students accepted our offer of admission; in addition, with a visiting student from Germany, and a transfer student from Engineering, we have welcomed 21 new graduate students in 2008!

Meanwhile, our graduating doctoral students have moved off as postdocs to prestigious positions, including a Green Scholar at Scripps Institution of Oceanography, and positions at Cambridge (UK), the University of Maryland, and the University of California Irvine, and a faculty position at Baylor University.

Our undergraduate majors have also made great strides. Last year they formed a new Geology Club, thanks to the initiative and leadership of **Abby Fraeman** and **Claire Bucholz**, both of whom are graduating this academic year and are destined for great things.

As with previous years, extensive renovations continue at Kline Geology Lab, including the development of three new state-of-the-art isotope geochemistry labs, a new diamond-anvil mineral physics lab, a new electron microprobe facility, and new teaching labs. As seen in the photo, we are transforming a large part of what was the Geology Library's space into a much needed office area for postdocs and visiting researchers.

Since 2007, our Department has been leading the effort to build a new Yale Climate Institute, designed to integrate science and engineering with social sciences throughout Yale on the critical problem of climate change and mitigation. This has involved a huge effort entailing a multidepartmental workshop in March of this year, which led to a major proposal that has been presented to the President and Provost. Negotiations over this proposal are ongoing at the time of this writing, but I hope to report on the establishment of this institute next year.

Finally, we have scheduled a Yale Geology & Geophysics Reunion in November of 2009 so that all our former graduate, undergraduate, and postdoc alumni can come visit old advisors and professors and meet the newest faculty,students, and scholars. Expect invitations to arrive in the months ahead.

It is a pleasure to report on the events and progress in our Department. I hope this Newsletter finds you well, and I wish you all the best for the coming year (and hope to see you in November of 2009!)

The Yale Sapphire. 121.9 carats and 4.5 cm in length, this superb specimen is on display in Peabody Museum's newly opened Hall of Minerals, Earth, and Space. The specimen was found in Myanmar several hundred years ago and was donated to the Museum by **Benjamin Zucker '62**.

FACULTY RESEARCH

Isotopes *continued from page 1*

Predicting the response of the global climate system to atmospheric changes is not straightforward. No laboratory experiments can be done to mimic such large-scale responses. Instead, we must examine the geochemical evidence of past climatic excursions in order to interpret the results of natural "experiments." Isotopic measurements are the major tools for such paleoclimate research.

My research focuses on developing and applying a new isotopic tracer, commonly called "clumped isotopes," to both carbon cycle studies and paleoclimate reconstructions.

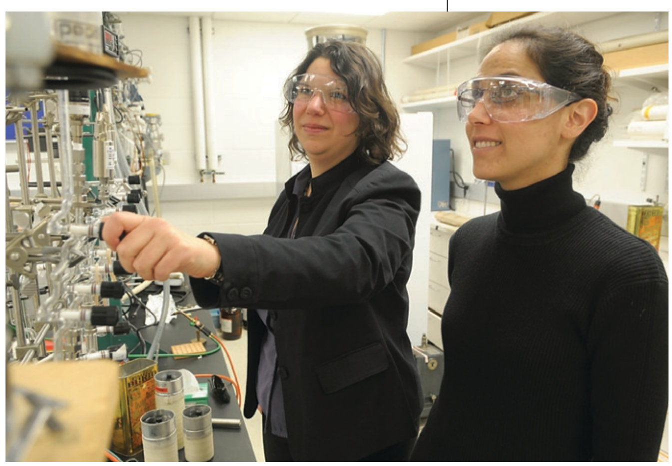
What are clumped isotopes?

Analysis of an isotopic composition determines the relative abundance of a heavy, rare isotope within a group of molecules. In CO_2 molecules, for example, this usually refers to measuring the abundance of either ^{13}C or ^{18}O within a vast majority of $^{12}C^{16}O_2$ molecules. Clumped isotopes are new isotopic tracers, which are based on a similar concept but what is measured is the natural abundance of molecules containing two heavy isotopes, such as $^{13}C^{18}O^{16}O$. A bond between two heavy isotopes is slightly stronger than a bond between two light isotopes, so that clumped isotopes are a measure for the slight preference of two heavy isotopes to clump together. A molecule containing two rare isotopes is very rare and the variations in its abundance are small. Measurement of clumped isotopes therefore requires specific instrumentation and patient and dedicated operators in order to achieve the necessary precision. Despite the difficulties of measurement, clumped isotopes can yield information that is not possible to obtain in any other way.

Paleoclimate reconstruction using clumped isotopes

The oxygen isotope compositions of carbonate minerals are widely used to reconstruct past climatic variations. But there is a major disadvantage in that isotopic compositions reflect a combination of variations in both the temperature and the isotopic composition of the water in which carbonate mineral grew (ocean water for marine records, and rain, soil, or lake water in continental records). Oxygen isotopes provide one measurement for an equation with two unknowns; an independent estimate of either paleotemperature or paleowater composition is therefore needed.

Thermometry using clumped isotopes provides a solution. The abundance of ^{13}C-^{18}O bonds in the carbonate mineral is a measure of the internal order within the mineral. For minerals growing at equilibrium the level of order is a function of temperature. Minerals forming at lower temperatures are more ordered, have relatively more ^{13}C-^{18}O bonds and therefore higher clumped isotope values. Minerals forming at higher temperatures are less ordered and have lower clumped isotope values. Because the bonds are an internal property of the carbonate mineral, they are independent of external parameters such as the oxygen isotope composition of the water in which the carbonate was formed.



Hagit Affek (left) with 1st year graduate student Shikma Zaarur (shikma.zaarur@yale.edu).

Thermometry by clumped isotopes was created by measuring synthetic carbonate minerals that were formed at known temperatures. A large collection of marine organisms followed the same temperature dependency (Fig. 1, upper panel). My current work focuses on applying clumped isotopes thermometry to continental climate records using carbonate cave deposits. Cave temperatures normally reflect annual mean surface temperatures, making speleothems an excellent, well-dated, archival material for efforts to reconstruct past climatic conditions on land. The combination of past temperatures estimated from clumped isotopes with the traditional oxygen isotope measurements may then elucidate past rainfall patterns.

I have measured clumped isotopes in samples from Soreq cave (Israel), which provide one of the classical speleothem oxygen isotope records (Fig. 1, lower panel). I found that, based on clumped isotopes, the last glacial maximum (20 Ky) in the Eastern

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Isotopes *continued from page 3*

Mediterranean was ~6°C colder than today. However, I also found that unlike carbonates of marine origin, modern speleothems do not fit the calibration of the clumped isotope thermometer, suggesting they are not formed at equilibrium. This is important as it reveals a potential complication also in the oxygen isotope interpretation of speleothem records and, of course, highlights the need for a specific calibration for speleothems when using clumped isotopes.

I currently study the processes that control this offset from equilibrium, in order to create an adaptation for speleothems of the clumped isotopes thermometer. In parallel, I continue studying the clumped isotope record of Soreq cave in an attempt to reconstruct past temperatures and rainfall patterns in the Eastern Mediterranean. The Eastern Mediterranean region, located at the edge of the desert, is climatically (and potentially politically) sensitive to variations in rainfall patterns that are predicted to result from future climate change. I intend to examine clumped isotopes in a variety of carbonate source materials in that region. With **Shikma Zaarur**, a newly arrived graduate student, I will study clumped isotopes in a group of plants that precipitate carbonate minerals in their seeds. Such seeds are found in several archaeological sites in the Levant and can be used for paleothermometry.

Clumped isotope thermometry can also be applied deeper in the geological record. **Alessandro Zanazzi**, a Bateman postdoc, will attempt to adapt it to carbonate in apatites, focusing on fossil bones that encompass the Eocene-Oligocene transition (37–32 My).

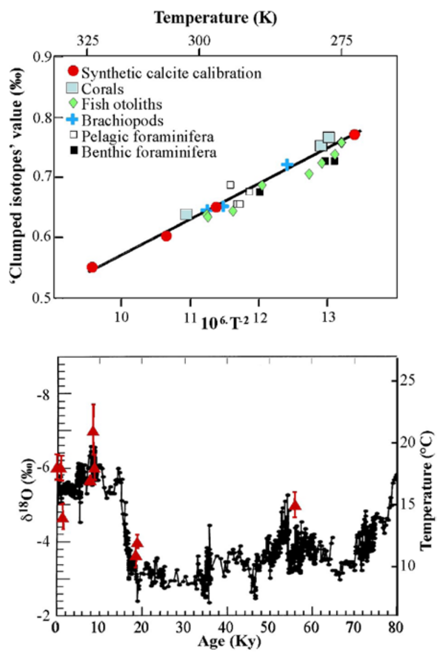

Fig. 1. Upper panel: Temperature calibration based on synthetic calcite grown in the laboratory under controlled temperatures. Marine biogenic carbonates generally follow the same temperature dependency trend. (Figure adapted from Eiler, 2000, EPSL, 262, 309-327). Typical 1SE is 0.005‰. Lower panel: Oxygen isotope composition in Soreq cave speleothems (black dots, part of a 185 Ky record; adapted from Matthews et al., 2000, Chem. Geol., 166, 183-191). Temperatures obtained from clumped isotopes, corrected to reflect a constant disequilibrium offset (red triangles; Affek et al., GCA, in press. doi:10.1016/j.gca.2008.06.031).

Clumped isotopes in atmospheric CO_2

Predicting future atmospheric CO_2 concentrations requires quantitative understanding not only of anthropogenic emission rates from fossil fuel combustion but also of the natural sources and sinks of CO_2. The budget of atmospheric CO_2 is widely studied using the concentration, plus the carbon and oxygen isotope compositions. However, the number and diversity of fluxes prevents these measurements alone from fully constraining the budget. My recent work has shown that clumped isotopes in atmospheric CO_2 can be used as an additional tracer for quantifying CCO_2 fluxes.

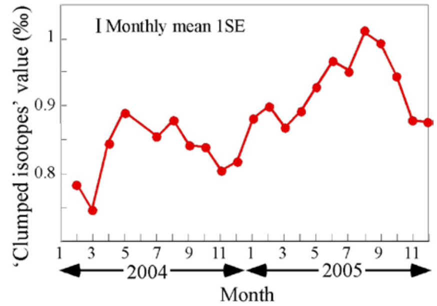

Fig. 2. Seasonal variations (monthly means) of clumped isotope values in urban air in Pasadena, CA (Affek et al., 2007, GCA, 71, 5033–5043). These variations cannot be fully accounted for by local fossil fuel combustion and reflect variations in local ecosystem activity.

This approach requires characterization of the isotopic values associated with all fluxes. I have started using clumped isotopes to study combustion and ecosystem respiration. Also required is the existence of measurable variations in the atmosphere. I have observed such atmospheric variations in the form of a seasonal cycle (Fig. 2) that is related to CO_2 exchange with the local ecosystem, suggesting that clumped isotopes can be useful for distinguishing between photosynthesis and respiration fluxes in addition to identifying CO_2 produced in combustion.

Clumped isotopes are new isotopic tracers, which are proving powerful in paleotemperature reconstruction using carbonate minerals. Clumped isotopes are also potential tracers for studying the modern carbon cycle and atmospheric CO_2, though this research is still much less mature and it is too early to predict its usefulness.

FACULTY RESEARCH

RETREAT: An International Seismological Investigation of Northern Apennines

by Jeffrey Park (jeffrey.park@yale.edu)

The tectonics of Italy are easy to describe but hard to explain. Italy provided many early ideas of modern earth science, but the Apennines, a substantial mountain chain, aligned roughly parallel to relative motion between Africa and Europe, remains poorly understood. To improve understanding, a team of Yale researchers is leading an international project called RETREAT, which stands for "REtreating-TRench, Extension and Accretion Tectonics."

The RETREAT acronym refers to a hypothesized causative factor behind the Apennines orogeny. Plate reconstructions starting 35 m.y. ago suggest a progressive opening of the western Mediterranean Sea by means of a subduction zone that swept backward (hence the term "retreat") from an initial location in the south of France. Swinging counterclockwise like a car door, pivoted near present-day Genoa on the Ligurian coast, the subduction zone is hypothesized to have consumed a large swath of lithosphere during the collision of the African and Eurasian plates. Active volcanoes like Stromboli and Vesuvius in the south of Italy are testaments to subduction, but in the Northern Apennines of Tuscany, and in Emilia-Romagna, the evidence of subduction is less clear. Marine sedimentary rocks of the orogen are no more than a few million years old, demonstrating recent uplift, and seismic tomography discerns a fast-wavespeed anomaly beneath the orogen, consistent with subducting lithosphere. So what is going on?

Jeffrey Park discussing RETREAT data with 3rd year graduate student Tara Mayeau (tara.mayeau@yale.edu).

With colleagues **Mark Brandon** and **Peter Reiners** (now at the University of Arizona), I organized an international program to investigate the subduction retreat hypothesis. Armed with a grant from the Continental Dynamics Program of the National Science Foundation (NSF), field studies in geochronology, tectonics, and seismology are helping to illuminate the issues. Multiple techniques were used to constrain past and present rates of surface uplift. Reiners, Brandon, postdoctoral associate **Stuart Thompson**, and Italian colleagues Massimiliano Zattin and Maria Laura Balestrieri measured fission-track abundances and radiogenic helium in apatite minerals found in near-surface rocks. Both helium and fission tracks accumulate only when rocks are sufficiently cool, so are less abundant in the case of rapid uplift. Rates of exhumation are estimated to be 0.5 to 1.0 mm/yr near the Apennines crest. By comparing helium and fission-track data from identical locations, we found an acceleration of exhumation at roughly 3 to 4 Ma, consistent with the rocks emerging from the sea at that time. Researchers from other US universities examined evidence for more-recent rates of uplift using cosmogenic nuclides in surface rocks, cave deposits, and fluvial terraces stranded through the uplift. These data suggest that exhumation rates have slowed to <0.5 mm/yr in the last million years.

The subduction-retreat model predicts a migrating deformation with matched belts of convergence and extension that initially raise surface rocks from below sea level into mountain belts, after which the orogeny undergoes extension and subsidence. In this model, Italy's Po River Valley and Adriatic Sea will be uplifted sometime in the future as the subduction zone backs into the area. By contrast, at the floor of the Tyrrhenian Sea, the subduction-retreat model predicts the eroded remnants of an old orogeny, left behind as the subduction zone migrates.

The objectives of the seismological phase of RETREAT were crustal and uppermost mantle structure. Of particular interest are

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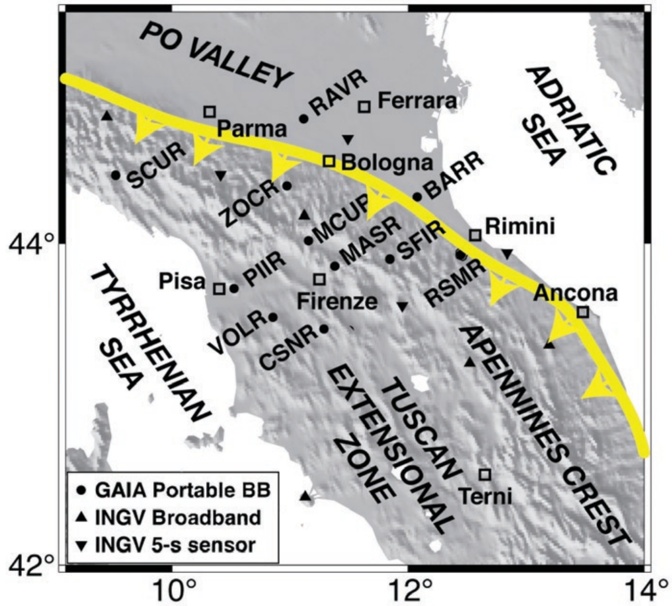

Fig. 1. Relief map of RETREAT field, with locations of major cities, geographical features, and the first-year deployment of seismographic stations. The yellow barbed line indicates the location of the hypothesized subduction plate boundary, along which the lithosphere beneath the Po Valley and the Adriatic Sea is thought to subduct beneath the Apennines orogen.

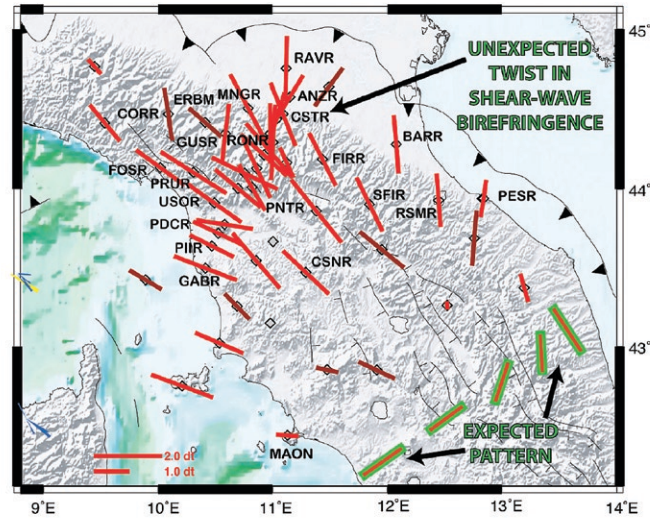

Fig. 2. Shear-wave birefringence, averaged values for each station in the RETREAT seismographic deployment. The red-line segments are plotted in the direction of fast shear-wave polarization. The length or the red-line segment indicates the average time delay between fast and slow polarizations. In the lower right corner we plot the birefringence pattern expected for the subduction-retreat model. The reorientation of fast-axis polarization near (11°E, 44°N) suggests a major departure from this model.

RETREAT *continued from page 5*

flow patterns expressed in the preferred alignment of olivine crystals in the mantle beneath the orogen, which leads to seismic anisotropy. Standard kinematic models of subduction make clear predictions of the mantle flow, which are testable using the birefringence of shear waves from earthquakes. The best earthquakes for our study originate far from Italy, for example, in Japan, New Zealand, or South America, far enough that shear waves must pass through Earth's liquid iron core as a pressure wave, so that a single shear-wave polarization ascends near-vertically from the core through the mantle. Olivine alignment in the upper mantle distorts this shear polarization, so that it splits into "fast" and "slow" polarizations that broadly align with the direction of mantle flow or mantle extension.

Together with colleagues from Rutgers, University of Southern California, the National Institute of Geophysics and Volcanology (INGV) in Italy, and the Geophysical Institute of the Czech Academy of Science (GFU), I installed and collected data from a portable seismic array consisting of 25 sets of portable equipment from PASSCAL (both STS-2 and CMG-40 sensors), 10 sets of portable equipment from GFU (STS-2 sensors), and 10 permanent installations of the Italian national seismic network (Trillium sensors). The array combined a relatively dense (~10 km spacing) linear transect across the Apennines orogen with a sparse two-dimensional network that covered a broader area. Seismic deployment began in October 2003. The last instruments left the field in September 2006. We encountered many challenges in the seismological field work: priests reluctant to place a seismometer in their sanctuaries, digging holes and mixing concrete for outdoor deployments in a driving rainstorm, and the stress of deciding which restaurant served the best lunch in villages surrounding each seismometer site.

In the first year, data from the first complement of seismic stations told us that shear-wave birefringence in the mantle beneath the Northern Apennines did not fit the expected pattern. The birefringence in other parts of Italy follows a pattern consistent with subduction retreat, namely, that mantle behind the subducting lithosphere is extended parallel to the Apennines as it tries to flow out of the way. In the Northern Apennines, it appears that this extensional strain is deflected to a high angle relative to the orogen, suggesting that subduction retreat is not the primary driver of mantle flow.

By great fortune the last seismic instruments were installed just in time for the great Sumatra-Andaman earthquake of 26 December 2004. The RETREAT seismometers recorded motions as large

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RETREAT *continued from page 6*

as 1 cm as the long-period surface waves (T >100 s) propagated across the network. Because the signals were so large, the portable instruments could detect smaller scattered waves that trailed the first surface waves. Such scattered waves are typically caused by anisotropy associated with mantle strain. Waveforms from the Sumatra earthquake were consistent with the geographical pattern of shear-wave birefringence, reinforcing our hypothesis that subduction retreat is not the primary driver of mantle flow beneath the Northern Apennines. Subduction retreat is consistent with some RETREAT observations, however. A thrust fault beneath the Apennine foothills was imaged in the shallow crust with exploration seismic techniques, consistent with active convergence at the place where Italian lithosphere is thought to be descending into the mantle. Efforts to extend this shallow fault from the upper crust to the mantle have not been successful.

Some RETREAT results have been published, documenting uplift estimates and the extreme complexity of the upper mantle deformation field. On the whole, the emerging picture from seismic data is not consistent with the scenario of ongoing trench retreat. Alternative views, such as stalled subduction and/or incipient slab detachment, pose intriguing challenges to observations derived from surface geology that imply past uplift and convergence, and perhaps present-day convergence as well. A final determination may depend on the longest duration part of the RETREAT project, a GPS network installed to monitor present-day surface motion. Preliminary data suggest weak convergence at the nominal subduction boundary in the Apennine foothills, overshadowed by extension across the Apennines crest, where a substantial normal-fault system has been associated with many damaging earthquakes.

It may be that subduction-retreat is largely responsible for the existence of the northern Apennines but has not been vigorously active for the past million years or more. Although the mountains of the Italian peninsula have been settled by ancient civilizations and studied by researchers from the dawn of geology, their underlying cause is complex and remains elusive.

RECENT AWARDS

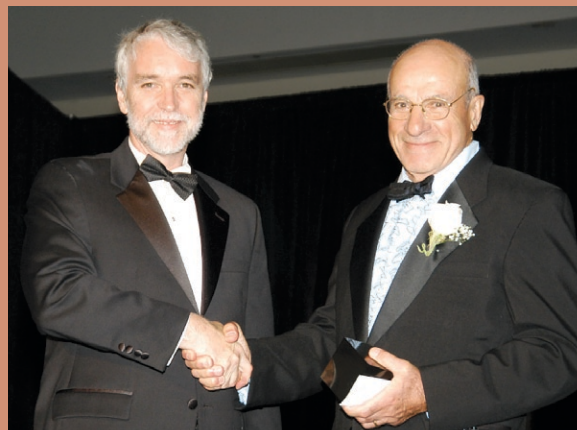
Leo Hickey lecturing to the stratigraphy class, Fall 2008.

Congratulations are in order for **Leo Hickey** (leo.hickey@yale.edu) who is to be the 2009 recipient of the Raymond C. Moore Medal, awarded by the Society of Sedimentary Geology (SEPM) for Excellence in Paleontology. Nominees for the medal are persons who have a significant record of outstanding contributions in paleontology, especially those aspects of paleontology that bear on a major objective of this Society, which is to promote the science of stratigraphy through research in paleontology and evolution, and the use of fossils for interpretations of paleoecology.

Brian Skinner (brian.skinner@yale.edu) has been made an Honorary Fellow in the Society of Economic Geologists by the SEG Council. He is the 12th person so recognized during the 87 years the Society has been in existence.

Srinath Krishnan (srinath.krishnan@yale.edu), entering graduate student in 2007, has been awarded the Schlanger Ocean Drilling Fellowship, awarded by the U.S. Advisory Committee for Scientific Ocean Drilling, for his proposal "Investigation of the global hydrological cycle during greenhouse-gas induced warming." The fellowship will allow Srinath to continue to focus his studies on important effects of global warming, such as perturbations of the water cycle.

RECENT AWARDS



George Veronis (right) accepting the Excellence in Education Award from Tim Killeen, President of AGU

The Geophysical Fluid Dynamics (GFD) program received the Excellence in Geophysical Education Award at the 2008 Joint Assembly Honors Ceremony, which was held on May 29, 2008, in Fort Lauderdale, Florida. The award honors "a sustained commitment to excellence in geophysical education by a team, individual, or group." **George Veronis** (george.veronis@yale.edu), cofounder of the GFD program, accepted the award from Tim Killeen, AGU President.

When asked to describe the GFD program, George wrote: "When I worked at Woods Hole Oceanographic Institution (WHOI) during the 1950s, Willem Malkus, Henry Stommel, and I had long discussions about the desirability of attracting young scientists with good backgrounds in physics and math to work on the many problems confronting us in oceanography and meteorology. WHOI had no education program at the time. In 1957 the launching of Sputnik shocked America and the US government was very receptive to anyone proposing a reasonable program for training scientists. So in 1958 I submitted a draft of a proposal to NSF and gave it to our director, who had contacts at NSF. The proposal was to take graduate students who had completed their coursework, teach them about the effects of stratification and rotation on fluid motions, and get them to work on a project during the summer. It was accepted by NSF and that was the birth of the GFD summer program at WHOI.

We quickly adopted the format that still exists: Two weeks of lectures by an expert on an aspect of fluid dynamics in the environment (which includes planets and even stars), and a beer-and-pizza evening during the second week during which the staff proposes problems which help the fellows (students) choose a topic to work on as a project for the remaining 8 or 9 weeks. The fellows must give a one-hour report on their progress at the end of the summer and submit a written report for inclusion in the volume for that summer. The main intent of the program is to train the fellows how to learn by doing research rather than by taking courses. That's the most difficult transition for graduate students to make and we manage to get them to do this in a ten-week period. We play softball together in the local league so that the fellows bond quickly and also realize that we are on their side on their research efforts as well as on the ball field.

We typically have 9 or 10 fellows, about the same number of full time staff, about 20 to 30 visiting (for a few days to a month) staff. None of the staff gets a salary but some of the visitors are paid per diem. None of the old boys have had even expense money for the past two decades. We have trained 455 fellows over the last 50 years and one of our alumni is the chief honcho at whatever GFD program exists anywhere in the world. More than 80% of our alumni are in academia or in government labs doing research. Up to 1990 we had a total of 16 female alumnae but we have averaged 3 females a year since then. We have 20 alumni academy members (that includes FRS etc.)."

Flint Lectures

David Battisti

The Richard Foster Flint Lectures on Paleoclimatology of the Late Cenozoic, Climate Dynamics and the Cryosphere.

The Flint Lectures originated after a landmark symposium at Yale when Professor Flint retired. The royalties from the book resulting from that conference entitled "The Late Cenozoic Glacial Ages" published by Yale University Press provided the base support for the successful series. Previous Flint visitors include John Imbrie, Cesare Emiliani, John Kutzbach, Wallace Broecker, Hans Oeschger, Nicholas Shackleton, G. Russell Coope, Lonnie Thompson, Jean Jouzel, Syukuro Manabe, Richard Alley, Peter deMenocal, and Edouard Bard, to name a few.

The Richard Foster Flint lecturer this year was David Battisti of the University of Washington. His three lectures were entitled: "Climate and Landscapes;" "El Nino/Southern Oscillation: Past, Present and Future;" and "A New Hypothesis for Dansgaard

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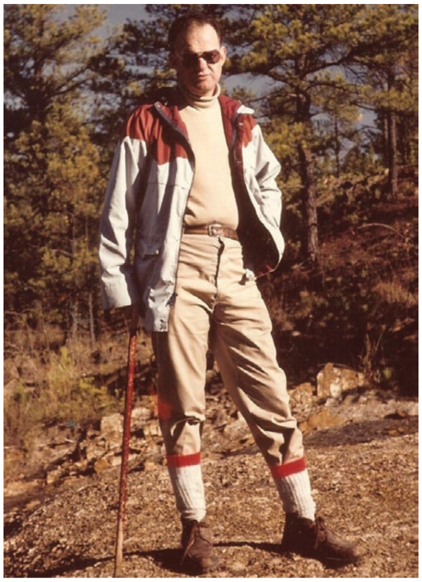
ALUMNI NEWS

We would especially like to hear from you. Please send your news to mabel.peterson@yale.edu.



Klein, at age 75, remains active as a petroleum geological consultant.

George Devries Klein G '60 (gdkgeo@earthlink.net) started his career at Sinclair Research in Tulsa as a research sedimentologist and moved to academe in 1961. He taught at the University of Pittsburgh, the University of Pennsylvania, and the University of Illinois @ Urbana-Champaign from 1973 to 1993. He then became President of the NJ Marine Sciences Consortium and NJ State Sea Grant Director. In 1996, he became a full-time consulting petroleum geologist and moved to the greater Houston area. As a consultant, he has discovered 160 million barrels of oil, and 3 trillion cubic feet of gas for clients (solo and as a team member).

George is the recipient of 11 awards for his research, including a Visiting Fellowship, Wolfson College, Oxford University (1969), the SEPM Best Paper Award (*Journal of Sedimentary Petrology*; 1972), a Senior Fulbright Research Fellowship in the Netherlands (1989), and the Lawrence L. Sloss Award of the Geological Society of America (2000). He is the founding chair of GSA's Division on Sedimentary Geology and served on editorial boards of four journals including the *GSA Bulletin* and *Geology*.

Pierre Biscaye (no hat, no hair) and Francis Grousset examining a small length of Greenland ice core in the Ice Core Freezer-Locker of Lamont-Doherty Earth Observatory (LDEO), Palisades, NY.

Pierre E. Biscaye G '64 (biscaye@ldeo.columbia.edu) writes: "Having worked in different aspects of oceanic sedimentation and sediment redistribution in my first 25 years at Lamont, and seeing application of some analytical techniques to the problem of eliciting climate and paleoclimate information from the insoluble (continental dust) particles in ice cores, I switched fields in the early 1990s and started working on the problem of the provenance of dust in ice cores drilled through the Antarctic and Greenland ice caps. The premise was that, if one could identify what desert or arid area(s) dust of a given age in an ice core had come from, one could constrain the atmospheric circulation pathways and models thereof by which it had been transported to the ice cap. Desert dust sources were identified by characterizing their particles mineralogically and in terms of their variable but stable radiogenic isotopes of strontium (Sr) and neodymium (Nd). My first attempt was in collaboration with my good friend and colleague, Francis Grousst (U. Bordeaux), along with some other Frogs. We determined that the dust in the first sample we studied, Last Glacial Maximum (LGM) ice from East Antarctica, had come from Patagonia in southern Argentina (Grousset et al., 1992).

Our next attempt was on dust in LGM ice from central Greenland, which we determined had originated in the Chinese and Mongolian deserts of eastern Asia (Biscaye et al., 1997). Despite having retired in 1999 (I got tired of working on "soft" money and spending so much time writing proposals), subsequent work has focused on samples from smaller and smaller time slices (8–10 days of modern snow, Bory et al., 2003).

More recent work has been in collaboration with Dennis Kent and Luca Lanci to see what kind of climate and paleoclimate information could be derived from the magnetic fractions of continental dusts (Lanci et al., 2007).

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Oeschger Events." In these lectures Professor Battisti intertwined model predictions based on the interaction of the atmosphere motion and geography on major climate patterns observed at present and projected to the past including the ice ages. This year's lectures represent the 23rd year of the series during which visits of prominent paleoclimatologists, climate dynamicists, and experts on the cryosphere have occurred.

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Patricia and Julius Dasch, with student Kellye Acuff between them.

E. Julius Dasch, Jr., G '68 (edasch@sulross.edu) writes: **"**After Yale I did a Fulbright Fellowship at the Australian National University, Canberra. I arrived just as ANU was receiving rocks from Apollo 11. I worked on a variety of isotopic studies there, with Bill Compston, Dave Green, and others. I began a teaching position at Oregon State University, Corvallis, in 1970, which I held until I changed jobs, to NASA Headquarters in DC. At OSU I worked on marine metalliferous sediments from the Nazca Plate, as well as on manganese nodules, and the strontium, lead, and neodymium isotopic composition of seawater.

At OSU I taught a new course "Rocks and Stars" derived from **Karl Turekian's** Meteorites course at Yale, which I loved. This led to an NRC fellowship, later a sabbatical at NASA JSC, working on moon rocks and meteorites. Then to a position at NASA Headquarters as the first Director of the NASA National Space Grant Program, modeled after the USDA Land Grant Program and the NOAA Sea Grant Program; I also took over the direction of NASA EPSCoR (Experimental Program to Stimulate Competitive Research), modeled after NSF EPSCoR. During my tenure at NASA, I took part in the Antarctic Search for Meteorites (ANSMET) program and was awarded the Frank Malina Medal for Excellence in Space Education. In DC, my wife Patricia, a native of the UK, began working for the National Space Society, as Editor-in-Chief for their magazine *Ad Astra*, and later as their Executive Director, until we retired in 2002.

We retired to Alpine, Texas, near Big Bend National Park. I am an Adjunct Professor of Geology at Sul Ross State University, where I did my undergraduate work. Pat and I teach "Rocket Science," a distance-learning course (with Midland College). The photograph shows us with one of our students, Kellye Acuff, who presented a poster (Partitioning of phosphorus and molybdenum between Earth's mantle and core) at the 2008 Lunar and Planetary Science Conference, Houston, Texas. We spend part of each year at our retirement apartment in Bridport, Dorset, UK."

Gary R. Feulner G '74 (grfeulner@shuaacapital.co) writes: "It was a pleasure to receive the now not-so-recent departmental newsletter, which I enjoyed very much, although the field has moved on (along with many of those I knew) since the childhood years of plate tectonics in the early 1970s.

I long ago left geology in favor of a professional career as a lawyer, but I have never abandoned my interest in the natural sciences or my love of the outdoors. For the past 25 years I have been a resident in the United Arab Emirates, where in my spare time I have been active in exploring and studying the many distinctive natural environments of the UAE and Oman—the deserts, the sabkha coastlines, and above all the mountains, which are largely comprised of the Oman ophiolite, the world's largest surface exposure of former mantle rock (I have logged far more time than most people "below the Moho").

Along the way I expanded my attention to include the local and regional flora and fauna, with a particular interest in biogeography (cultivated long ago by a freshman course taught by the late Robert MacArthur). One result is that I have authored the (so far) definitive studies of the UAE's freshwater fish and freshwater and land snails, as well as publishing more selectively on, *inter alia*, butterflies, dragonflies, mountain plants, intertidal mollusks, local climatic periodicity and tail-signaling in mountain geckoes. Geologically, I have published a popular account of the general geology of the UAE as well as

Gary R. Feulner

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more specialized papers on geomorphological oddities: several mountain streams which fork in the downstream direction (an early stage of stream capture), including one whose twin channels straddle the "continental divide" between the UAE's two coasts.

I am frequently asked what role, if any, my graduate school training has played in my subsequent life, given that I did not go on to a scientific career. For me, the answer was always easy: It played a tremendous role because it cultivated the discipline of careful and critical investigation, analysis, and exposition. These are useful in any field of intellectual endeavor. Of course there were some particulars that I associate with Yale as well. Foremost among those would be the tradition of what is most delicately called "robust intellectual debate" (exemplified in memory by **Karl Turekian**) and the important principle (again, applicable much more broadly) that you can estimate anything if you make enough assumptions.

I invite any Yale geologists to contact me if they are visiting or passing through the UAE. This is more likely than you might think, since Dubai is a major transit hub, but be warned: For the past decade I have been chairman of the Dubai Natural History Group, so I am always on the lookout for visiting lecturers! It was a happy occasion to make the acquaintance recently of Prof. Andrew Hill (Dept. of Anthropology) and G & G graduate student, **Faisal Bibi**—both in the field at one of Faisal's sites where Miocene elephant footprints are exposed. At a somewhat later date I journeyed the two hours to Abu Dhabi to hear Andrew speak on current Yale paleontological research.

Robin (Lincoln) Petrusak '79 (rpetrusak@adv-res.com) is a project manager and consulting geologist for Advanced Resources International in Arlington, Virginia, a research and consulting firm providing services related to unconventional natural gas reservoirs (coalbed methane, gas shale, low permeability ("tight") sandstones), enhanced oil recovery, and geosequestration of carbon dioxide. Robin provides resource assessments, CO_2 storage capacity assessments, and reservoir evaluations for private and government clients. Current work for the Southeast Regional Carbon Sequestration Partnership includes reservoir evaluation and capacity assessment of potential Cretaceous-age CO_2 storage reservoirs and seal formations. Other recent consulting projects include reservoir evaluation for domestic gas shale developments and resource assessments for international coalbed methane projects.

Early in her career, Robin spent 10 years with Amoco Production Company in Denver, Colorado (now BP), as a petroleum geologist and petrophysicist. Robin worked on a number of natural gas development projects in the Green River, San Juan, and Denver basins. She later earned an M.Sc. in environmental science from the University of Colorado-Denver and worked briefly in the environmental remediation services industry before relocating to the Washington, D.C. area in 1998.

Prior to joining Advanced Resources in 2005, Robin was a consultant with ICF International, Fairfax, Virginia, on environmental regulatory and policy issues pertaining to the petroleum industry, including exploration and production wastes, air emissions, greenhouse gas emission inventories, and greenhouse gas emission reduction strategies.

Duane E. Mellor '80 (duane.mellor@yale.edu) writes: "I entered the Geology & Geophysics Ph.D. program in 1973, fresh from my undergraduate years at Rice University. Under the direction of the late **Karl Waage,** I did my preliminary research and fieldwork on the Upper Cretaceous Almond Formation of Wyoming. After receiving my M.Phil., I realized that academia wasn't the appropriate path for me. Still, I couldn't bring myself to leave KGL entirely, so I took a position in the Geology Library—and stayed 27 years.

Clearly a creature of habit, I fully expected to retire from my desk in the Library. However, in 2004, when a position became available on the joint Union-Management Job Search Team, I couldn't resist applying. I'd been an elected officer of Local 34, the union of Yale clerical and technical employees, since 1985. (I currently serve as Secretary-Treasurer). The Job Search Team, which was established during the 1992 labor negotiations, is comprised of two management and two union representatives. Its charge is *"to supplement University placement services and job counseling especially as they relate to laid-off Staff Members."* As an employment counselor and troubleshooter, I spend my days interviewing and assisting laid-off clerical and technical employees

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with a goal of finding them another position in the university. It's the best of all worlds: a Yale job, a supportive Team, and an office in the Union Hall.

In addition, I represent Local 34 and its members in a broad range of other Union-management partnership activities. The work is hard and the hours are long, but the job satisfaction is through the roof.

I live in Madison, putting my liberal politics in action by commuting to work on Shore Line East. In addition to my civil union partner, Leighton Carlson, I share the house with two dogs and a cat. I'm having the time of my life."

Mike and Danita in Germany; photo by their son.

Michael A. Velbel G '84 (velbel@msu.edu)**/Danita Brandt G '85** (brandt@msu.edu) write about the challenges they faced as a married couple in academia. "We knew when we decided to get married that we would face considerable challenges in finding two jobs in our respective disciplines (geochemistry and paleontology) within commuting distance of each other. The first 5 years of our professional lives were spent commuting between a drafty farmhouse located about half-way between East Lansing (Michael's position at Michigan State University) and Ypsilanti (Danita's position at Eastern Michigan University). The decision to start a family complicated some things, but clarified others—the commute, farmhouse, and one of the positions would have to go. The decision of which position to keep was determined by institutional status and salary, and we moved to East Lansing, where we gladly gave up the second car and the commuter lifestyle to live within walking distance of campus. Danita's detour from the tenure-track lasted 16 years (not coincidentally corresponding to raising fledglings to college age). Regaining tenure involved a measure of serendipity (the right opportunity coming along at the optimal time) and much perseverance. Working in the same department presents other challenges; we take pains to maintain a professional relationship at work and consider ourselves successful when our students are surprised to find out that Drs. Brandt and Velbel are related. Advantages to being in the same field include having a travel companion/roommate for professional society meetings, coauthoring the occasional paper, coteaching a few classes, and having a reliable drinking buddy (see photo), but probably the most important advantage is that each of us understands the pressures and stresses the other faces in the academic world (particularly in regard to grant-getting and irascible journal editors/reviewers). And, of course, our shared professional path stems from a common alma mater and wonderful cadre of classmates from our time at Yale."

Julia Clarke G '02 (julia_clarke@ncsu.edu) reports that she has been appointed as a tenured

Julia with a penguin skull.

Associate Professor in the Jackson School of Geosciences, University of Texas, Austin. She takes up her new post in January 2009.

After completing her Ph.D., Julia spent two years as a postdoc at the American Museum of Natural History in New York, working with **Mark Norell G '89**. Her first faculty appointment was in the Department of Marine, Earth, and Atmospheric Sciences, North Carolina State University, where she was an Assistant Professor starting in 2004.

Julia continues to work the emergence of all kinds of living birds and the emergence of extant avian diversity. She has developed a special interest in penguin evolution and climate change through the Cenozoic (penguins fossils are known back in the early Paleogene, about 61 m.y. ago).

Walter Joyce, G '04 (walter.joyce@uni-tuebingen.de) will be joining the faculty of the Institute of Geobiology of the University of Tübingen, Germany, as an Assistant Professor in January 2009. After

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Walter in Slope County, North Dakota, while excavating a turtle site in the Hell Creek Formation.

receiving his Ph.D. from Yale, Walter accepted the position of Collections Manager for the Division of Vertebrate Paleontology at the Peabody Museum of Natural History. During this time, Walter was able to continue his research on vertebrate evolution through fieldwork in Utah, New Mexico, Montana, North Dakota, and Abu Dhabi. Walter looks forward to devoting more time to the origin and evolution of turtles while in Germany but expects to remain affiliated with the Peabody Museum.

James A. Stevenson G '04 (James.Stevenson@LDHEnergy.com) writes: "After completing my Ph.D., I returned home to Sydney, Australia, with my wife Gretchen. In Australia I worked as a risk analyst in the energy trading team at Eraring Energy, a generation company with coal, hydro, and wind generation assets. After enjoying all the cricket, rugby, and meat pies that I possibly could, I returned to Connecticut in early 2008. Since then I have been working as a commodity trading analyst at Louis Dreyfus Highbridge Energy in Wilton, CT, focusing on international and US


James Stevenson and wife Gretchen.

coal, along with US and European natural gas and power. The geology and mathematics skills that I learned during my Ph.D., and my experiences in energy trading in Australia, were instrumental in helping me get the position. I'm currently living in Black Rock, CT, with Gretchen and 2 kittens, and still hang out with many of the friends I met in G & G at Yale."

The Peabody Awards 2008 Gaylord Simpson Prize

The recipient of this year's George Gaylord Simpson Prize is **Jakob Vinther** (jakob.vinther@yale.edu), a doctoral student in the Department, for his paper "Machaeridians are Palaeozoic armoured annelids," co-authored with Peter Van Roy and Derek E. G. Briggs (*Nature* 451(10): 185–188, January 10, 2008).

Originally from Denmark, Vinther has been interested in fossils and evolution since he was a child. His research focuses on the radiation of animals at the beginning of the Cambrian (540 m.y. ago), specifically on how mollusks and annelids diversified to the groups we know today. By incorporating both molecular biology and fossils from the Yale Peabody Museum collections in this research, he seeks to reconstruct the tempo and mode of organismal evolution that took place in a rapidly changing biosphere and to understand their functional adaptations to life in specialized ecological niches. The machaeridians are an excellent example of the adaptive radiations taking place in early animal evolution. These annelid worms (relatives of earthworms and leeches) evolved a mineralized armor, which gave them an ability to explore niches similar to mollusks. The machaeridians went extinct, however, after existing in the world seas for more than 180 m.y.

Each year the Yale Peabody Museum of Natural History awards the George Gaylord Simpson Prize to a Yale University graduate student or recent doctoral candidate for a paper concerning evolution and the fossil record. The prize is named for **George Gaylord Simpson** (1902–1984; Yale Ph.D. '26), one of the most influential paleontologists of the 20th century and a major proponent of the modern evolutionary synthesis.

INVOLVEMENTS IN SOCIETIES

Mary J. Kraus '73 (Mary.Kraus@Colorado.edu) has been a professor at the University of Colorado since 1983, and she is currently Chair of the Department of Geological Sciences. She is a former Editor of the *Journal of Sedimentary Research* and has just completed her term as President of the Society of Sedimentary Geology in 2007-08. Her research interests include alluvial paleosols and their geologic utility, alluvial architecture, processes of floodplain construction, and continental ichnology. Mary's current research focuses on paleosols that formed at the Paleocene-Eocene Thermal Maximum and their significance for interpreting climate change at that time. That research is with fellow Yale alumni **Francesca Smith '92** and **Scott Wing '76, G '81**. She lives in Boulder with her husband (David Uhlir, Tufts '83) and two teenage daughters.

Neil Williams G '76 (neil.williams@agso.gov.au) is currently President of the Society of Economic Geologists (SEG). Seen here, he is speaking to a student group at the recent SEG meeting in South Africa. Neil is currently the Director of Geoscience Australia.

Cathy Skinner and Jean Bahr

Jean Bahr '76 (jmbahr@geology.wisc.edu) (right) is Vice-President of the Geological Society of America and will presumably become President next year. Jean is seen here with Cathy Skinner in a photo taken at the GSA's awards and Presidential address ceremony at the annual meeting in Houston, Texas; Jean had just finished chairing the ceremony. Jean is Professor of Hydrogeology, University of Wisconsin, Madison. She has just completed a term as Chair of the Department of Geology and Geophysics.

Derek Briggs (derek.briggs@yale.edu) completed his two-year term as President of the Paleontological Society in the Fall of 2008. Derek, who is the Frederick W. Beinecke Professor of Geology and Geophysics, is the newly appointed Director of Peabody Museum.

IN MEMORIAM

John Shelton

John Sewall Shelton G '47 of La Jolla, California, died peacefully at home on July 24, 2008. He graduated from Pomona College in 1935 and after a year of teaching geography at the Francis Parker School, where he found himself especially excited by the educational possibilities of taking local field trips, he decided to pursue geology at Yale. In 1941 Shelton moved his family back to Claremont in order to fill a mid-year faculty position in the Pomona College Geology Department, and completed his Ph.D. thesis on "Miocene volcanism in the northeastern part of the Los Angeles Basin, California" in 1947. He taught at Pomona until 1957 when he took a leave of absence to write "Geology Illustrated." This famous textbook contains over 200 of his own photographs taken from the air along with companion illustrations done by his artist brother, Hal Shelton. In 1999 "Geology Illustrated" was named one of the 100 best science books of the 20th century by *American Scientist*.

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IN MEMORIAM

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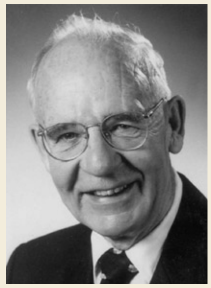
It was during his first years at Pomona College that Shelton became a pilot and developed his skills in taking aerial photographs while piloting his own plane. His immense collection of photos taken from the 1940s to the 1980s throughout the western parts of North America is still in great demand for usage in textbooks and for teaching at all levels of education

John received the American Geological Institute award for "Outstanding Contribution to the Public Understanding of Geology for singular accomplishments in capturing geological processes on film" in 1993. In 2002 he received the National Association of Geoscience Teachers "Neil Miner Award" for "exceptional contributions to the stimulation of interest in the earth sciences." The first public exhibit of 33 of his large-format photographs, "Aerial Portraits of the American West," is now on display at the San Diego Natural History Museum in Balboa Park, CA.

John was passionate about how students should be taught: experience something first, then ask questions about how it might be explained; don't explain first and show later.

John was also an avid tennis player, having played the game since he was a boy—he put down his racquet only after competing in a "90s and over" doubles tournament in 2003, and he was nationally ranked several times in both singles and doubles.



Ward Neale G '52 died on May 19, 2008, after a long and influential geological career in Canada. After war service with the Royal Canadian Navy, Ward graduated from McGill University in 1949, then came to Yale for his Ph.D. He worked with Professor **Matt Walton** on his thesis titled "Geology of the Bethoulat Lake area, Mistassini Territory, Quebec." Returning home, Ward first joined the Geological Survey of Canada, then Memorial University of Newfoundland, where he rose to Vice-President (Academic). He served as President of the Canadian Geoscience Council and the Geological Association of Canada. In 1995, the E. R. Ward Neale Medal was established to recognize outstanding achievements in public awareness of earth science. Among his many distinctions and awards were membership in the Royal Society of Canada, honorary degrees from the University of Calgary and Memorial University; the Order of Canada, and the Ambrose medal from the Geological Association of Canada.

Karen Von Damm

On August 15, 2008, **Karen L. Von Damm '77** died after a bout with liver cancer. Karen worked with **Karl Turekian** on her senior thesis on the chronology of Mirror Lake sediments at Hubbard Brook. She stayed on at Yale for a year after graduation to participate in the laboratory measurement of ^{210}Pb in ocean water profiles of the GEOSECS (Geochemical Ocean Section Studies) expeditions of which Yale was a part. She moved on to do her Ph.D. with the late John Edmond at MIT.

She was Professor of Geochemistry at the University of New Hampshire. Karen was a renowned investigator of ocean hydrothermal systems associated with spreading centers. She made numerous dives aboard the submersible ALVIN and deciphered the chemistry of hydrothermal waters.

She was highly regarded professionally and her many scientific collaborators and friends have expressed a feeling of great loss. Yale also will miss this distinguished alumna.

The New Postdoc Quarters on the Third Floor of KGL

Photo taken from the same position as photo of David Bercovici on front cover. Space in the foreground was previously the back of the library reading room. Space in rear was previously a computer lab.

Details of a new postdoc's cubicle.

Shun Karato conferring with postdoc Justin Hustoft in the conference area.

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