



# The Smilodon

The Princeton Geosciences Newsletter - Spring 2001 Vol. 42 No. 1

## PLUMBING IN ICELAND: Imaging Plate Formation in the Earth's Interior

The volcanoes of Iceland have long been a source of fascination for writers and scientists. Jules Verne started his "Journey to the Center of the Earth" at one, Snaefell. Old tales tell of the belief that the souls of the condemned traveled through another, Helka, on their way to hell due to its similarity to Dante's depiction of the gates to hell. Just as Iceland's unusual landscape has inspired authors, it has also drawn Earth scientists, making Iceland one of the most intensely studied places on Earth.

**Guust Nolet** and **Jason Morgan \*64, Faculty**, working with graduate student **Richard Allen \*01** have recently completed a study imaging the Earth's interior beneath Iceland. The aim of the study was to better understand the processes responsible for Iceland's very existence. The result is an image of a vast plumbing system feeding hot and molten rock from a deep mantle plume up through the crust into volcanoes and rift zones on the surface (Figure 1) and providing new evidence in support of the plume hypothesis.

The view from a plane on final approach to Iceland's international airport is enough to explain the attraction of Iceland to those interested in solid Earth processes. The recently erupted

black rock surface, which extends across the Reykjanes Peninsula, is broken by the parallel knife cuts of faults resulting from the separation of Europe and America. It is only a short drive from the airport to volcanoes, glaciers, hot springs, geysers (Figure 2) and Geysir — the geyser after which all others are named — and thundering waterfalls (see <[www.icetourist.is](http://www.icetourist.is)> for a virtual tour). Further inland the landscape is barren, often flat with no vegetation, covered by lava flows and ash. In fact, it is so moon-like that Neil Armstrong and the other Apollo astronauts spent time training here before their trip to the Moon.

Iceland remains just as fascinating in the context of larger scale global processes. Figure 3 is a perspective view of the North Atlantic bathymetry. To the east and west the tops of continental shelves are seen in red above the deep ocean basin. Down the center of the basin the ocean floor shallows due to the buoyancy of hot new plate freshly formed along the Mid-Atlantic Ridge. The existence of Iceland is due to a huge swell in the ocean floor causing it to rise above sea level exposing the plate-forming processes, which usually take place 2.5 km beneath the waves.

The unusual bathymetry, gravity anomalies and volcanic activity of Iceland and other oceanic islands, such as Hawaii, led **Morgan** to propose his mantle plume hypothesis in 1971. The plume model is an explanation for the chains of volcanic islands found across the floor of ocean basins parallel to plate motion. The observation calls for a stationary heat source beneath the oceanic lithosphere as a plate passes by. The model suggests that a thermally buoyant plume anchored in the lower mantle and rising to the surface provides the necessary continual stream of hot material.

In the summer of 1996, **Nolet, Morgan** and **Allen** went to Iceland as part of a team of American, Icelandic and British scientists for the deployment of the HOTSPOT project. Thirty seismometers on loan from the IRIS-PASSCAL instrument pool, funded by the National Science Foundation (NSF),



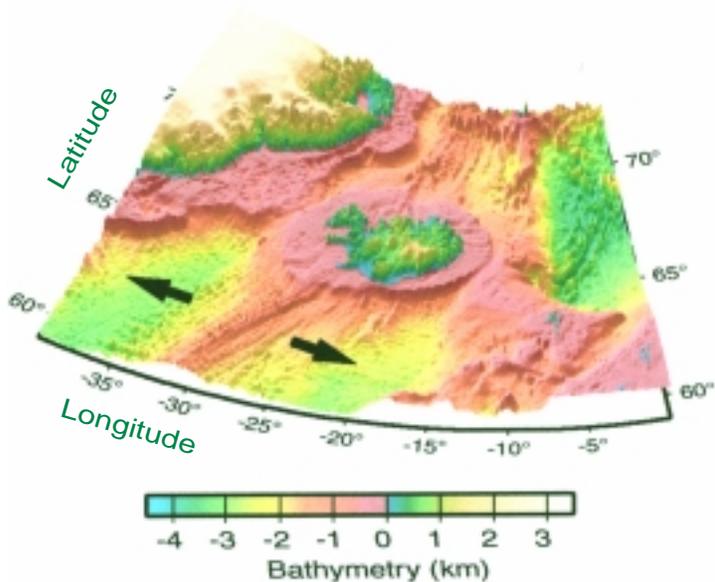
*Figure 1. The Krafla rift zone in eruption. Photo by Allan Rubin, Faculty*



**Figure 2.** The Strokkur geyser. Photo by *Richard Allen \*01.*

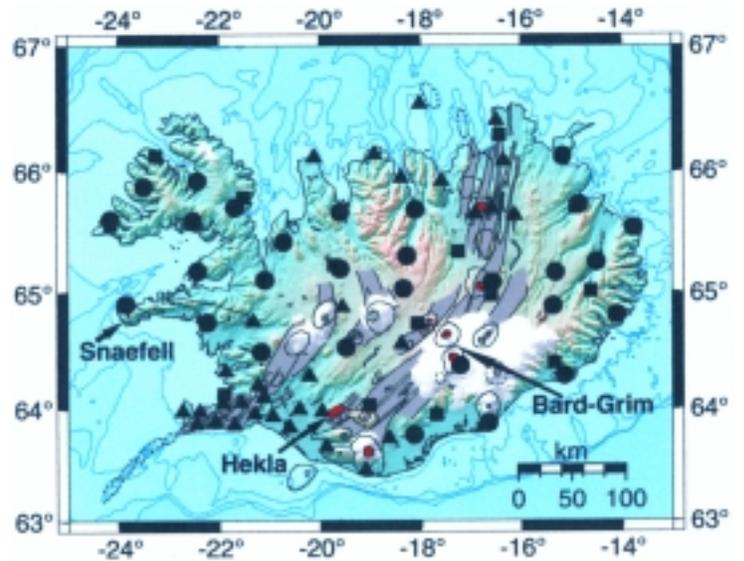
were positioned in Iceland to record ground motion continuously for two years. The instrument locations are shown as circles in Figure 4. Most of the data used came from these stations. However, two additional networks were also used: the permanent SIL (Southern Iceland Lowland) network (triangles in Figure 4), which is operated by the Icelandic Meteorological Office to monitor seismic hazard in populated regions, and the ICEMELT network (squares). Figure 4 also shows some of the geology of Iceland. The wide gray areas are fissure swarms, the product of the Mid-Atlantic Ridge crossing Iceland. All along them are volcanoes represented as thin black rings. The six most active volcanoes on Iceland are shown in red.

The seismometers recorded thousands of earthquakes from both Iceland and around the world, providing a data-set that can be used to determine the internal structure of the Earth. The technique used—seismic tomography—is similar to a CAT



**Figure 3.** Bathymetry of the North Atlantic. Iceland (shown in the center) protrudes from the ocean basin sitting on a large swell shown in red. The red regions to the east and west are the European and Greenland continental shelves marking the edges of the ocean basin, which is up to ~3 km deep in the North Atlantic. It shallows in the center where hot new plate is formed. The plates move apart as shown by the arrows.

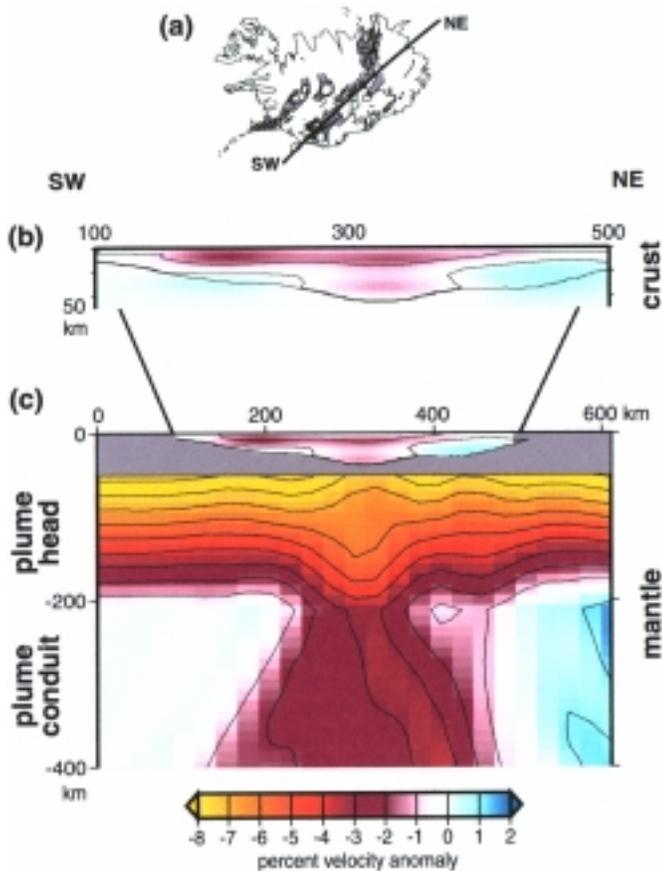
scan where x-rays are shot through the body at many different angles and recorded by many detectors on the other side of the body. Seismic tomography uses the energy from earthquakes around the world, which travels through the Earth and is recorded by many stations with seismometers installed on the surface. Variations in the velocity at which seismic energy travels through different rock causes the earthquake signal to arrive at slightly different times at the different seismic stations. By measuring these differences it is possible to construct a three dimensional map of seismic velocity in the Earth's interior, but only over a volume to a depth about equal to the horizontal extent of the seismic array. These variations in velocity are then interpreted in terms of rock properties. While many properties affect the velocity, temperature and presence of melt droplets have the most significant effect, both high temperatures and melt cause low velocities.



**Figure 4.** Map of Iceland showing the seismic stations used, topography and geology. The stations are shown in black, most data come from the HOTSPOT network (circles). Data was also used from the SIL (triangles) and ICEMELT (squares) stations. The wide gray regions are fissure swarms representing the Mid-Atlantic Ridge on Iceland currently undergoing extension. Glaciers are white and active volcanoes are red.

Nolet, Morgan, Allen and their co-workers from England and Iceland used recordings from over 300 earthquakes recorded at 78 stations to construct their images of velocity variations beneath Iceland. What was different about their study is the sheer volume of data used and the variety of tomographic techniques used to construct the images. They combined the use of surface waves, which travel horizontally, with body waves that are predominantly vertical beneath Iceland. The criss-crossing nature of the energy from these different waves allowed resolution of both the near surface crustal structure (upper 50 km of the Earth) and the deeper mantle structure (down to ~400 km depth), something which has not been possible previously.

The result is visualization of a vast plumbing system as shown in Figure 5, which is a vertical cross-section through the crust



**Figure 5.** Vertical cross-sections through the crust and mantle models. (a) Map of Iceland showing the location of the cross-sections. (b) Crustal cross-section (enlarged relative to c). The low velocities (red) extend vertically through the lower crust up into the upper crust where they extend along the rift. (c) Cross-section through the crust and mantle illustrating the plume conduit from 400 km to 200 km, the plume head above 200 km, and the thickest crust above the center of the mantle plume.

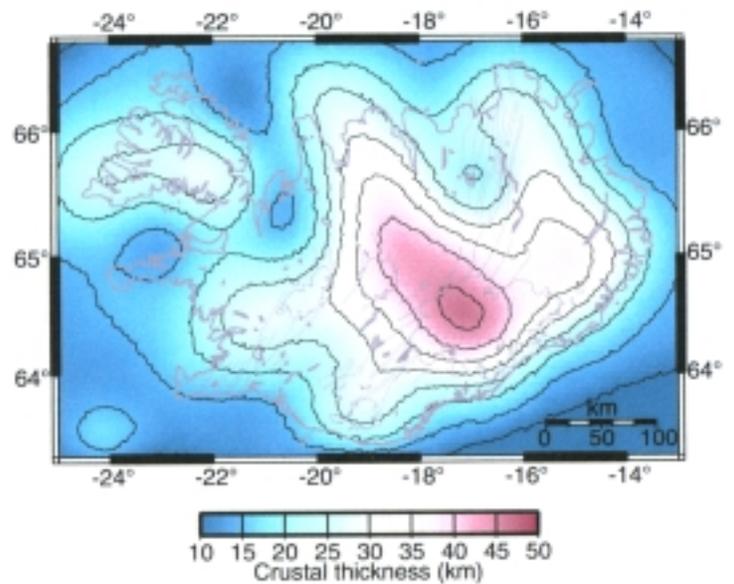
and mantle beneath Iceland. The largest scale processes are seen in the mantle portion of the image. From 400 km depth up to 200 km there is a vertical low velocity zone which is cylindrical in three dimensions. They interpret this as being a plume conduit, the low velocities being due to high temperature rock, which is thermally buoyant and flows up towards the surface. When it reaches the surface it is forced to flow horizontally outwards forming a plume head. This is also clear in Figure 5c above 200 km depth. The plume head had not been observed previously; but it is visible in their study because they combine surface wave and body wave data.

The effect of the plume on plate formation processes is clear in the crustal thickness variations in Iceland. Figure 6 is a map of crustal thickness derived from surface waves using earthquakes in Iceland during the HOTSPOT experiment. The thickness of oceanic crust is remarkably constant around the world (6 +/- 1 km). In Iceland, however, the thinnest crust is ~15 km thick, the thickest—found in central Iceland above the center of the mantle plume—is 46 km thick.

The mantle plume connects to crustal pipes which feed melt from the plume up into the crust. This is shown in Figure 5c. The crustal velocity variations are superimposed on the mantle

model. The mantle immediately beneath the crust down to 50 km has been grayed out so the variations in crustal thickness are visible. The crustal velocity variations are shown enlarged in Figure 5b. The thickest crust is directly above the center of the mantle plume, beneath central Iceland (see location of cross-section on insert map, Figure 5a), and is also associated with low velocities in the lower crust.

A vertical cylinder of low velocity extends through the lower crust up beneath the Bardarbunga-Grimsfjall Volcanic Complex, which is the most active volcanic complex in Iceland, most recently erupting in 1996 and 1998. This observation leads **Nolet, Morgan and Allen** to suggest that the low velocities are a thermal halo resulting from the passage of magma up to the volcanoes. What is surprising is that there are no such vertical pipes beneath any of the other active volcanoes in Iceland. Instead there is a horizontal low velocity zone in the upper crust which extends along the Mid-Atlantic Rift to the north and south of central Iceland (shown as the gray fissure swarms in Figure 4). This suggests that magma is fed from the plume vertically up through the lower crust and into the upper crust where it is able to flow laterally along the rift to supply Iceland's other active volcanoes and the very process of plate formation.



**Figure 6.** Crustal thickness across Iceland. The thickest crust (46 km) is in central Iceland above the core of the mantle plume today. It is the thickest because the plume is more active today than it has been over the last 20 million years.

**Nolet, Morgan and Allen's** visualization of the mantle plume beneath Iceland provides another piece of evidence in support of **Morgan's** plume hypothesis. The crustal plumbing, however, is new, previously unresolved in Iceland, although a similar structure was recently imaged beneath another part of the Mid-Atlantic Ridge on a smaller scale. Their interpretation of the crustal anomalies as magma plumbing will need further testing by the Earth science community. For example, a comparative geochemical study of Iceland's volcanoes could provide further clues.

*This article was prepared by Richard Allen \*01. ■*

## Robert Bruce Horsfall: American Natural Science Illustrator

In the footsteps of his predecessors, Benjamin Waterhouse Hawkins (1807-1889) and Charles Robert Knight (1874-1953), **Robert Bruce Horsfall (1868-1948)** turned some of his artistic ability to the painting and drawing of reconstructions of extinct animals. Among them is the *Smilodon* profile that graces the seal of the Princeton Geological Association.

After studying at the Cincinnati Art Institute and spending four years in Munich and Paris **Horsfall** returned to Cincinnati to paint for the Rockwood Pottery Company and opened his own studio. In 1898 he moved to New York where he painted portraits and was a freelance illustrator for several science magazines. He became a pioneer in the development of pictorial background for habitat groups and his paintings were used by Yale University's Peabody Museum, University of Minnesota, and Rutgers and Princeton universities.

**Horsfall** came to Princeton in 1904 to illustrate the extinct animals brought back by Princeton's Expedition to Patagonia and field trips to our western states by **Professor William B. Scott \*1877**. In 1909 he was appointed staff artist for William Beebe's expedition to Borneo, India, and Ceylon. Later he painted for the Bronx Zoo, the American Museum of Natural History, and *The Nature Magazine* in Washington, DC.



*Early bison charcoal drawing by Horsfall in the Princeton collection.*

In his later years he moved back to Princeton to work in our Museum of Natural History. Hanging in the Guyot Hall stair well are his portraits of **Professors Alexander H. Phillips '1887\*1899, Faculty 1887-1937, and William John Sinclair, Faculty 1905-1934**. He was a prolific artist and most of his work he left to his good friend, the late Helgi Johnson, Professor of Geology at Rutgers University, where that collection remains. ■



*Imaginary evolution of the horse depicted in a reproduction of an oil painting by Horsfall.*

## Whence Came the Princeton Geological Association

The Princeton Geology Club, organized in 1911, was derived from the Natural Science Society of Princeton. As members of the club graduated and moved away from Princeton, they felt a need for an organization that would keep them in touch. In 1915 **Professors Gilbert Van Ingen** and **Benjamin F. Howell '13 \*20** (as secretary) organized the Princeton Geologists' Association that included all Princetonians interested in geology, paleontology, and mineralogy.

The first meeting was held in Washington, DC, December 29, 1915. Twenty-three members joined, and it became an annual function to hold a dinner for members during the joint meetings of the Geological Society of America, the Paleontological Society, and the Mineralogical Society of America. The principal by-law of this association was to "bind together in a permanent organization the men...connected with the Department of Geology...in order that they may be kept in closer touch with each other."

At the December 1925 meeting in New Haven, **W. A. Kelly \*25** announced the plans for the publication of a newsletter, *The Smilodon*. That name was used for a 22-page edition in 1926. It contained a history of the department by **William Berryman Scott '1877**, several obituaries, other articles, and "a directory of past and present members." Sometime after this Bruce Horsfall is thought to have painted the Association seal, part of which is now used on the cover of *The Smilodon*. There were probably other issues following the 1926 issue - unrecorded in the archives of the department - possibly organized by **Professor Howell**. "The first issue of the revived journal" was in January, 1934, and was recorded as Volume 1, No. 1.



*The Smilodon Seal - The original painting by Bruce Horsfall was prepared for the Princeton Geological Association in the 1920's and was used for the modern newsletter from 1934 to 1942. Rejuvenated in 1970 after 28 years, the modern Smilodon carries the same seal, but without the departmental name — it having gone through several name changes.*

In 1936 the Association had 136 members. At that time a proposal was announced to acquire for \$10,000 real estate belonging to **Professor W. Taylor Thom** in Montana to be used as a research camp, which eventually evolved into the Yellowstone-Bighorn Research Association (YBRA). The President of the Geological Association at that time was **Reuben J. Ross '13** who took steps to legally incorporate the Association in New Jersey as the Princeton Geological Association. After World War II the department gradually took over the planning of gatherings at national meetings and sponsorship of the present-day *Smilodon*. Its main goals having been established through the department, the Association was formally dissolved when **Sheldon Judson '40** was departmental chairman. ■

## Around The Department

In February **Ants Leetmaa** became the Director of the Geophysical Fluid Dynamics Laboratory (GFDL) of the National Oceanic and Atmospheric Administration (NOAA). He replaced **Jerry Mahlman**, who had been Director from 1984-2000. **Leetmaa** had been the Director of the National Weather Service's Climate Prediction Center in Camp Springs, MD.

Congratulations! On February 26th our head librarian, **Patty Gaspari-Bridges**, was given a major new set of responsibilities in her role as Assistant University Librarian of Special Libraries. She is now responsible for all of Princeton's science and technology libraries, and will direct the planning for the future of the new consolidated science library, including all aspects of its collections and services.

Congratulations to our **Debbie Smith** who has been promoted to Department Manager.

Welcome to the new post-docs. **Brian Schlottmann** is an NSF Fellow from the University of Texas. He will be working on seismic waves with **Guust Nolet** and **Tony Dahlen, Faculty**. Also working with **Nolet** and **Dahlen** is **Ileana Tibuleac**, from Southern Methodist University. **Christopher Francis**, a Hess Fellow, is working with **Bess Ward, Faculty**. He comes from the University of California at San Diego.

Welcome to Post Doc Research Associate **Yung-Yuan Ho** from SUNY at Stony Brook, NY, a chemical oceanographer working with **François Morel, Faculty**. Carrying out research on trace elements, **Makoto Saito** is also working with **Morel**.

From the Center for Human Values, **Stephanie Resko** has joined the staff to replace **Laurie Wanat**, who has become the Web Coordinator.

Farewell to **Duane Moser** who has gone to the Pacific Northwest National Laboratory, Richland, WA. He will still collaborate with **Tullis Onstott \*81, Faculty**, on the Witwatersrand Deep Microbiology Project in South Africa. **Shu-Huir Hung** has left for a faculty position at Taiwan University. **Michael Ward** has left the department.

The 250th Anniversary Visiting Professor for Distinguished Teaching is **Gregory van der Vink \*83**. The topics for his classes are natural hazards, arms control negotiations, global warming, beach erosion, ozone depletion and environmental regulations. This class Geo/Env 299 is under the direction of

this department and the Princeton Environmental Institute (PEI). Over 235 students across the four classes are enrolled, which necessitates the help of the following faculty for the 170 who elected a laboratory section: **Lincoln Hollister**, **Jason Morgan \*64**, and **Robert Phinney**; undergraduates are **Anne-Marie Barrett '02**, **Trevor Walsh '01**, and Scott Steele, a biology graduate student. Too large a group for Guyot 10, lectures are held in McCosh 10.

On March 29th, **Barbara Smith Grandstaff \*73** gave a *Sigma Xi* lecture on "Princeton University's Natural History Museum Research: Venerable and On-going." **Barbara** wrote the article on the museum in the last issue of *The Smilodon* and now she reviewed the museum, its present fate, and hopes for the future. She teaches at the University of Pennsylvania and is on the staff of the New Jersey State Museum.

**Late Flash:** **Tony Dahlen** has been named by President Shapiro to succeed **George Philander** as chair of the Department in July. ■

## News

<e-mail address>

A fax from **George Morgan '38** from Spain saying he is a grandson of the late **Francis Speir, '1877** (see *The Smilodon*, v. 41, No. 2, Fall 2000). "As a little boy I knew Wade Speir's father when his father was a Princeton student and came to visit my grandfather in South Orange. His father was later a physician in New York and I have always regretted not having gone to New York to meet him." *The Smilodon* seems to be delving into genealogy.

A very welcome fan letter from **Carmen Ridland \*39** praising the last edition of *The Smilodon* which contained so much history of Guyot Hall and this Department.

A nostalgic letter from **Shelby Lee '42** remembering the World War II years at Princeton.

After 45 years with the U. S. Geological Survey in Menlo Park **Preston Hotz \*49** has moved to Santa Rosa, CA, to be with his daughter and family. He said it was like "going home," because he grew up in Sonoma.

**James MacLachlan \*52** taught at Metropolitan State College of Denver from 1967 to 1987 and then retired. He says that he and his wife, whom he met at Princeton when she worked for **Glenn Jepsen '27 \*30**, **Faculty** are trying to travel to places they haven't seen, or want to revisit.

A notable lawyer in New York City and an ardent environmentalist, **Constantine Sidamon-Eristoff '52** has put to good use his knowledge from the geological engineering classes of the late **Taylor Thom, Professor 1926-56**. **Sidamon-Eristoff** served as Highway Commissioner for the city and then Transportation Administrator. He has spend 15 years on the Board of the Metropolitan Transportation Authority and then on the Environmental Protection Agency. He'll be back for his 50th Reunion. <cseristoff@LLTLaw.com>

**Glenn Poulter \*57** has been retired for two years and spends half his time in Arizona and half in Colorado. He attended his 50th reunion at the Colorado School of Mines.

**Bruce Greenwood**, the son of **Hugh Greenwood \*60**, **Faculty 1962-1967**, is an actor and is now playing the role of John F. Kennedy in the movie, "Thirteen Days," which has just opened.

An e-mail from **Fred Brown '63** who has moved to Clermont, FL, to be near his kids and grandkids. After medical school he and his family were medical missionaries in Haiti for 5 years. Later, he served as a doctor in the emergency room mostly in Miami. <FGBEDMDJBB@aol.com>

**Lynn Glover III \*67** retired in 1995 from Virginia Polytechnical Institute and State University. In retirement he enjoys Hispanic studies, travel, and service in alumni relations for his department there. <LGlover@vt.edu>

**Col. Sam Boehm '71** will spend his last four years as a drilling reservist with the U. S. Army Reserve prior to retirement at age 60. He's in the Army Medical Corps in Miami. <Boehmsp@aol.com>

In Pittsburgh, PA, **Robert Kleinman \*79** is working with the National Energy Technology Laboratory in charge of a research group involved in mine drainage, coal by-products, gas hydrates, etc. He also edits the journal, *Mine Water and Environment*. <Robert.Kleinmann@netl.doe.gov>

**Jonathan Husch \*82** travelled to Cuba as Rider University's NCAA Faculty Athletics Representative on a *People to People* delegation of university-level administrators and educators. While there he managed to look at some Jurassic isoclinally-folded limestones containing ammonoids.

Now a full professor at the University of California, Santa Barbara, **Cathy Busby \*83** will be an AAPG Distinguished Lecturer for 2001-2002. She is also an officer of the Society for Sedimentary Geology. <cathy@geol.ussb.edu>

After 6 years with the Lawrence Livermore National Laboratory **Peter Fiske '88** accepted a position as vice president for marketing and business development with RAPT Industries in Livermore, CA., a startup company that he co-founded this year. <PeterFiske@home.com> (See Books)

**Amy Kneeder '89** Donahue is now an assistant professor teaching graduate students about public and urban affairs and political science at the University of Connecticut. At the moment her research is concentrated on fire protection and emergency services. <donahue@uconnvm.uconn.edu>

After an 11-year stint with ARCO **Van Mount \*89** has joined Anadarko Petroleum Corporation's Basin Studies Group in Woodlands, TX.

In 1996 **Chris Weaver '91** got his Ph.D. from Scripps, then stayed on a year as a post-doc. He's been at Rutgers University in New Brunswick, NJ, for over a year as an Assistant Research Professor in the Center for Environmental Prediction.

In Bethesda, MD, **Harvey Cohen \*92** is a senior project geologist at Papadopulos and Associates working on ground water and environmental projects. He also serves on the GeoRef advisory committee of the American Geophysical Union (AGU). He reports that **Remy Hennet \*87** has been promoted to a Principal with the company after 11 years. <HCohen@sspa.com>

Completing her Ph.D. degree at MIT, **Kirsten Findell '92** (by the time this gets mailed) has returned to Princeton as a Visiting Scientist in the AOS program. Her thesis was in hydroclimatology, more precisely, *Atmospheric Controls on Soil*

*Moisture-Boundary Layer Interactions*. She will be working on the representation of river flows in the Global Climate Model program at the Geophysical Fluid Dynamics Laboratory (GFDL) on the Forrestal Campus. <kirsten@alum.mit.edu>

**Chris Parker Sarason '93** wrote as the Seattle earthquake of February 28 was under way, saying, "So that's what a 7.0 feels like!" He was in a recently-built University of Washington building, so it wasn't too scary. He says, "the best story by far was by one student, just out of the shower who thought, "Oh no...I don't have any clothes on and they're going to evacuate!"

Last November **Michael Deal '97** returned to conduct ExxonMobil interviews. He is with the company in Houston.

After several other jobs **Justin Bennett '99** is now working for RAM Environmental Engineering Services, Inc. in Bakersfield, CA. He's aiming to become a registered geologist.

**Bill Langin '99** is a second-year graduate student at Cornell concentrating in seismology and geophysics. He is working with Project INDEPTH to determine the crustal structure and evolution of the Tibetan Plateau. <langin@geology.cornell.edu>

Moving to Corpus Christi, TX, **Kate Fleeger '99** is training to be a pilot.

**Kalliopi Monoyios '00** is working at the University of Chicago as a fossil preparator. <goahead@hotmail.com>

**Hadley Owen '00** is writing grant proposals for a non-profit performing arts theatre in New York City. ■

*Put Your Science to Work: The Take-Charge Career Guide for Scientists*, by **Peter Fiske '88**, 2000, Special Publication, AGU, 179 pp., \$19.95. \$13.95 AGU members.

An update of **Fiske's** 1996 career guide, *To Boldly Go*, on how to achieve success now. ■

## Honors

An award has been established in memory of **Gabriel Dengo '49** to be given for excellence in presentation of a technical paper. The recipient's name will be placed on a silver cup, which will be kept at the American Association of Petroleum Geologists (AAPG) headquarters in Tulsa.

Congratulations to **François Morel, Faculty**, who has been awarded a Guggenheim Foundation Fellowship for the year 2001-2002.

Honorary Membership has been awarded to **William B. Heroy, Jr., '41**, who has retired to Durham, NC. This is given to those who have distinguished themselves by their accomplishments and service to the profession of petroleum geology.

**Steve Stanley '63** is the President-elect of the American Geological Institute (AGI). He will continue as a professor at Johns Hopkins University in Baltimore. <stanley@jhu.edu>

**Jim Murray '64** was awarded the Alberta Science and Technology Society's premium prize for outstanding contributions to the development of the science and technology community in Alberta, Canada.

The Department of Geology and Geophysics at the University of Wisconsin-Madison has awarded **James D. Robertson '70** a Distinguished Alumni Award for the year 2000. This was given for his distinguished scholarly contributions in geophysics, outstanding service to the hydrocarbon industry, and outstanding professional service.

Reviewers cited by the editors of the American Geophysical Union (AGU) journals for excellence in refereeing are: **Thomas Brocher '78**, **Robert M. Key**, **Research Oceanographer** in this department, and **Michele Cook '89**.

A candidate for AAPG elected editor, **John Lorenz '81** is a distinguished member of the technical staff of Sandia Laboratory in Albuquerque. ■

## Alumni/ae Reception at Reunions

As usual  
The Department will host a reception  
for those returning for Reunions.

Friday, June 1  
3:00 to 5:00 PM  
In Guyot Hall

We plan to give an update on  
the renovation and major new construction  
plans for the Guyot Hall Complex,  
including the new Museum and  
Science Library

Come visit with faculty and students

## Books

*Deepwater Sandstones, Brush Canyon Formation, West Texas*, Field Guide for AAPG Hedberg Field Research Conference, by R. T. Beauboef, **Fred B. Zelt '85**, and others., 1999, AAPG Continuing Education Course Note 40, 48 pp., \$59.00. AAPG members \$39.00.

Exceptional exposures of submarine fan complexes.

*Remote Sensing of Active Volcanism*, by P. J. Mouginiis-Mark and **Joy Crisp '84**, 2000, AGU Geophysical Monograph Series, Vol. 116, 274 pp., \$66.00. AGU members \$46.20.

Earth scientists will find the most current methodologies and data for remote sensing of eruption volcanoes.

## Deaths

**William Noble Lockwood '33**  
June 22, 1994

**Louis Rodman Page, Jr. '41**  
December 18, 2000

**Frank Reinhart Reichel '51**  
October 3, 1999

**Harris Bates Stewart '45**  
April 25, 2000

## From the Archives...



*In 1956, Joe Kalliokoski \*51, Faculty 1956-68, took his Mineral Deposits class down an anthracite mine near Coaldale, PA. Joe was cleaning up his photo collection and sent this for the Departmental Archives. Thanks, Joe.*

*Left to right: Ron Nelson '57, Jay Lehr '57, Roy Olson '57, Hugh Cannon '57, Mr. McRaabe, John Whetton '57 \*62, Mr. X, Bill Booker '57, Prof. Kalliokoski, Ben Morgan \*67, Ed Shover '57, Pete Wallis, Pete Lavin '57, James Schuck '57.*

### Look how we've changed!

In case you hadn't noticed, *The Smilodon* has undergone a facelift and makeover. We're still working the bugs out, but we hope you like the new look.

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Princeton, New Jersey 08544-1003

*Return Service Requested*

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#### THE SMILODON

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