

Vol. II  
No. 01  
Winter, 2011



# Geologic Times

DIVISION OF GEOLOGICAL & PLANETARY SCIENCES

## In this issue

Faculty & Alumni News & Awards	p.2
Postdoctoral & Student Awards	p.3
Mars Science Laboratory	p.4/5
Student Enrichment Trip to Peru	p.6/7
In Memoriam—Thomas J. Ahrens	p.8
About the Division	p.9

## MARS SCIENCE LABORATORY



CALIFORNIA INSTITUTE OF TECHNOLOGY

*New Faculty***Andrew F. Thompson**

Assistant Professor of  
Environmental Science and  
Engineering

*Arriving Summer, 2011*

I received a B.A. in Engineering Sciences from Dartmouth College in 2000, a M.Phil. in Fluid Flow from Cambridge University in 2002, and a PhD in Physical Oceanography from the Scripps Institution of Oceanography in 2006. After a year as a postdoc at the University of East Anglia, I returned as a NERC Postdoctoral Fellow at Cambridge University.

My research focuses on the impact of mesoscale processes on the global ocean circulation. Ocean mesoscale is similar to atmospheric weather patterns, but differences in the properties of air and water cause ocean structures (e.g. eddies, fronts) to be ten times smaller than their atmospheric counterparts, leading to more complex flows. I am especially interested in the Southern Ocean, which connects the ocean basins and regulates the transport of heat between these basins and the margins of Antarctica, both key components of the global climate system. I use both numerical models and observational data, and I have participated in two research cruises in the Southern Ocean. I will return south next year to deploy new autonomous underwater gliders near the tip of the Antarctic Peninsula.



**Jean-Philippe Avouac**, Professor of Geology and Director of the Tectonics Observatory, has been chosen to receive a Humboldt Research Award for Senior U.S. Scientists. Valued at 60,000 Euros, the award is made "to academics whose fundamental discoveries, new theories, or insights have had a significant impact on their own discipline and who are expected to continue producing cutting-edge achievements." Winners are invited to spend up to a year cooperating on a long-term research project with specialist colleagues at a research institution in Germany. A 1987 graduate of École Polytechnique, Avouac received his doctorate from University of Paris VII in 1991 and his habilitation in 1992. He joined Caltech's faculty in 2003 and was appointed director in 2004.



**John P. Grotzinger**, Fletcher Jones Professor of Geology, was the recipient of the Geobiology & Geomicrobiology Division award this year for his outstanding contributions to the field of science. This award was presented at the annual GSA meeting in Denver, CO.



**Yuk L. Yung**, Professor of Planetary Science, was elected as an Academician of Academia Sinica, Republic of China, by the 29<sup>th</sup> Convocation of Academicians held from July 5-8, 2010 in Taipei Taiwan.

*Faculty Awards*

**Woodward Fischer**, Assistant Professor of Geobiology, has been chosen by the European Geosciences Union (EGU) to receive its 2011 Outstanding Young Scientist Award for the Division of Biogeosciences. The award will be presented at the EGU General Assembly, to be held in Vienna, April 3-8. Fischer received his BA from Colorado College in 2000 and his PhD from Harvard in 2007. He joined Caltech's faculty in 2009.

*Alumni Award*

**Jeanne L. Hardebeck**, Geophysics PhD, 2001, is a 2010 recipient of the PECASE (Presidential Early Career Awards for Scientists and Engineers) award. This is the highest honor bestowed by the United States government on science and engineering professionals in the early stages of their independent research careers.

Jeanne is currently a Research Geophysicist with the United States Geological Survey Earthquake Hazards Team in Menlo Park, CA.

### Postdoctoral Scholar Award



**Bin Chen**, the Texaco Postdoctoral Fellow, is the 2010 recipient of the John C. Jamieson Award. The Jamieson Award is given for outstanding achievement in the field of high pressure research by a graduate student or postdoctoral researcher. This award is given every year, alternating at the Gordon Research Conference (Research at High Pressure) in one year and the AIRAPT Conference the next year.

### Student Awards



**June Wicks**, 3rd year graduate student in Geochemistry, has received the 2010 ASCIT Teaching Award. Wicks also received the Division's 2010 Richard H. Jahns Teaching Award. Originally established in 1990 as the Robert P. Sharp Teaching Award, its purpose is to recognize a selected student for "outstanding achievement as a Graduate Teaching Assistant" during the academic year just completed. The award is presented at the annual Division Zilchbrau. The first awards were presented in 1990, after which, at Dr. Sharp's request, the name of the award was changed to honor a former faculty member of this Division.



**Michael Line**, 3rd year graduate student in Planetary Science, was awarded the Keck Institute for Space Studies Fellowship (KISS).

The following graduate students were awarded fellowships from the National Science Foundation Graduate Research Fellowship Program (NSFGRFP):



**Daniel Stolper**  
2nd year graduate student in  
Geobiology



**Kristin Bergmann**  
3rd year graduate student in  
Geology



**Kaitlyn Lucey**  
3rd year graduate student in  
Environmental Science and  
Engineering



**Ajay Limaye**, 3rd year graduate student in Planetary Science, was awarded the National Defense Science and Engineering Graduate Fellowship (NDSEG).



**YoungHee Kim**, 6th year graduate student in Geophysics, was awarded a scholarship from the Society of Exploration Geophysicists (SEG). This year the SEG is honoring 138 students at universities in 21 different countries for outstanding accomplishments in geophysics.

### New Faculty



**Heather Knutson**  
Assistant Professor of  
Planetary Science  
Arriving Summer, 2011

I was born in southern California and grew up on an island called Kwajalein, located approximately halfway between Hawaii and Australia. Despite this early stint in the tropics I've spent most of the past decade on the east coast, earning a B.S. in physics from Johns Hopkins University in 2004 and a Ph.D. in astronomy from Harvard University in 2009. More recently, I made the leap back to the west coast where I am currently a Miller Postdoctoral Fellow at UC Berkeley. My research focuses on characterizing the atmospheres of planets orbiting nearby stars, including their temperatures, compositions, and weather patterns.

The planets I study are too far and too faint to resolve directly, therefore I use observations of eclipsing systems, where the planet periodically passes in front of and then behind its parent star, to infer their properties. Many of these unique worlds have characteristics that differ substantially from those of the solar system planets, and observations of these systems allow us to study the potential diversity of planetary atmospheres and provide an important testing ground for atmosphere models.



John P. Grotzinger, Fletcher Jones Professor of Geology, is a field geologist interested in the evolution of surficial environments on Earth and Mars. His research addresses the chemical development of the early oceans and atmosphere, the environmental context of early animal evolution, and the geologic factors that regulate sedimentary basins. He works on creating the basic geologic framework for sedimentary basins and orogenic belts in northwest Canada, northern Siberia, southern Africa, Oman, and the western United States. These field-mapping studies are the starting point for more topical laboratory-based studies involving geochemical, paleontological, and geochronological techniques.

Currently, he is the Chief Scientist for the Mars Science Laboratory Rover mission, due to launch in late 2011. He is also a member of the Mars Exploration Rover Science Team, and HiRISE camera imaging team on Mars Reconnaissance Orbiter.

[www.gps.caltech.edu/~grotz](http://www.gps.caltech.edu/~grotz)

A long-standing goal of Mars environmental studies has been to understand the role of water throughout its geologic history. The presence of water is a strong indicator of formerly different environmental conditions, as well as of potential habitability. Prior to studies by the Mars Exploration Rovers, most studies of water-related processes had been based on analysis of geomorphic attributes. However, we can now examine the record of past surface processes, including the role of water, through sedimentologic studies of the stratigraphic record of Mars. Many processes that operate at a planetary surface have the potential to create a record of sedimentary rocks. Sedimentary rocks can provide clues that allow past environmental conditions to be reconstructed, including those that might have promoted microbial processes, and their preservation as fossil organic compounds. Recent rover and orbiter missions to Mars show that sedimentary rocks are surprisingly common. Constrained to be billions of years old, these rocks are remarkably well preserved and represent diverse eolian, fluvial, deltaic, and evaporitic environments.



chemical, isotopic, and mineralogical composition of the surface and near-surface materials; investigate planetary processes of relevance to past habitability, including the role of water and carbon dioxide; and characterize the broad spectrum of surface radiation.

A habitable environment is “one that has not only water, but also a source of carbon to make organism metabolism possible, and a source of energy to fuel that organism metabolism” (Grotzinger, 2009). MSL will search for organic carbon in rocks, soils, and the atmosphere, as well as the mineralogical diversity of the rock and soil chemistry. MSL is not a life-detection mission, but it will be able to detect complex organic molecules in rocks and soils, which could be of biological origin, or from carbonaceous meteorites (Grotzinger, 2009). MSL will also be able to evaluate the concentration and isotopic concentration of gases such as methane. Searching for habitable environments is difficult though because the degree to which organic carbon would be preserved on Mars is unknown.

This approach holds both the hope and promise of Mars Science Laboratory. The hope is that MSL may find some signal of a biologic process. The promise is that MSL will deliver fresh insight into the comparative environmental evolution of the early stages of Mars and Earth. That alone is a valuable prize. The MSL payload was specifically assembled for the purpose of environmental (and paleoenvironmental) assessment and includes: a gas chromatograph-mass spectrometer and gas analyzer that will search for organic carbon in rocks, soils and in the atmosphere; an x-ray diffractometer that will determine mineralogical diversity in rocks and soils; color cameras that can image landscapes and rock/soil textures in unprecedented resolution; an alpha-particle x-ray spectrometer for *in situ* determination of rock and soil chemistry; a laser-induced breakdown spectrometer to remotely sense the chemical composition of rocks and minerals; an active neutron spectrometer designed to search for water in rocks and soils; a weather station to measure modern-day environmental variables; and a sensor designed for continuous monitoring of background solar and cosmic radiation.

The overall scientific goal of MSL is “exploring and quantitatively assessing a local region on Mars as a potential habitat for life, past or present”

(<http://msl-scicorner.jpl.nasa.gov/ScienceGoals/>). There are four primary science objectives in order to meet the overall habitability assessment goal: assess the biological potential of at least one target environment by determining the nature and inventory of organic carbon compounds; characterize the geology of the landing region at all appropriate spatial scales by investigating the

The MSL landing site will be chosen from a list of four final candidates. These sites optimize the chance to encounter low energy sedimentary environments that may preserve organic matter. Evaporites are strong candidates because of their known potential to preserve organic matter. Another important target would be clay-rich minerals deposited in fluvial, deltaic or lacustrine settings. The detection of these environments is based on orbital remote sensing, using spectral data from CRISM and OMEGA, and image data from HiRISE, CTX, THEMIS and MOC to map depositional sequences and predict where fine grained rocks and evaporites are likely to occur.

When not working on MSL's rover, Curiosity, Grotzinger oversees the MSL Landing Site Working Group. This work involves assessment of potential geologic targets for each site, mapping regions of interest, identifying and compiling hypotheses for the science targets, and developing plans that would test these hypotheses, including possible traverses. John is also involved in planning community workshops for selecting a MSL landing site. The selection of the MSL landing site is done through a series of community-led, open workshops that have occurred in parallel with the design and development of the spacecraft.

The current candidate landing sites are Eberswalde Crater, Gale Crater, Holden Crater and Mawrth Vallis. These finalist sites have passed preliminary checks against engineering and safety criteria, though data acquisition and analyses are ongoing. From a scientific standpoint, sites with mineralogical (phyllosilicates or sulfates) and/or geological evidence (depositional fans, fluvial systems) for past aqueous activity, as detected from orbit, are thought to be the most relevant for the MSL science objectives and payload. The landing ellipse is currently 25 x 20 km, but expected to become more refined as the process continues. Landing will occur in late northern summer on Mars (August 2012).

#### References:

Grotzinger, J.P. 2009, Beyond Water on Mars. Nature Geoscience, v. 2, p. 1-3



For more information on the MSL mission, go to:  
<http://mars.jpl.nasa.gov/msl/mission/overview/>

For more information on the MSL landing sites go to:  
<http://marsweb.nas.nasa.gov/landingsites/>

## Student Enrichment Trip to Southern Peru

September 15-26, 2010

by June Wicks and Melanie Channon

In September 2010, 15 GPS Division students joined professors Rob Clayton, Mark Simons, Pablo Ampuero, and future assistant professor Victor Tsai on a ten-day excursion to southern Peru. The students got a glimpse of the people and places that are part of the Peru Subduction Experiment (PeruSE), a joint venture between the Caltech Tectonics Observatory and the UCLA CENS. The tour took the students on a loop through the cities of Lima, Arequipa, Juliaca, and Cusco and nearby cultural and archaeological sites. Traditionally, a division trip is offered every year, with international trips offered periodically. These international trips are intended to expose GPS students to the cultural and historical context of geologically interesting locations.



Two of the most striking features of central and southern Peru are the Altiplano plateau and the flat-slab subduction of the Nazca Plate, neither of which are well understood. The seismometers of PeruSE are placed strategically in three lines to image the unusually thick continental crust and subducting slab, and we were able to visit one such seismometer on a Vicuña preserve/research center. We left our mark on the experiment's dataset by organizing a group jump around the instrument. Volcanoes in southern Peru are abundant and in some cases recently active; we saw the volcano El Misti quietly waiting beside the city of Arequipa, and elsewhere saw evidence of hydrothermal activity as hot springs, fissures, and land slumping. Other geological highlights included a trek across the Atacama Desert to witness the Barcchan sand dunes formed from volcanic ash and the expansive Colca canyon, twice as deep as the Grand Canyon and home to the beautiful Andean condor.

One memorable aspect of the trip was our ability to see evidence of the pre-Incan civilizations, the Inca Empire, and the Spanish colonization regionally preserved alongside the modern cultural and political Peru. We started our trip with an impressive introduction to the pre-Colombian pottery at the Larco anthropology museum in Lima, saw their still-used agricultural terraces lining the valley walls of Colca canyon, and marveled at the tomb towers of the Aymara people at Sillustani. The Inca construction was equally impressive, as we experienced at the towering gate to the sacred valley called Runicolca, the expansive fortress of Sacsayhuaman, and the fortified royal estate of Ollantaytambo.

The Spanish architecture decorated the countryside and cities with churches. We visited the San Francisco Cathedral in Lima, complete with catacombs full of bones, and the brightly painted Santa Catalina convent in Arequipa, which still houses nuns today. Everywhere we looked in the towns we could see political advertisements from elections past, and we

experienced second-hand the political demonstrations in Cuzco in the form of roadblocks (which we circumvented on dirt roads) and train/airport strikes, which were exciting for the students and worrisome for those in charge. Miraculously, our timing fell together perfectly and we spent our last full day exploring the ruins of Machu Picchu. It was the perfect grand finale to a wonderful trip!

We students would like to thank Rob Clayton for meticulously organizing this trip and pre-trip lectures, his tireless saves when plans changed last-minute, and for making sure we were fed and entertained. We are also grateful to Peru-based Richard Guy and Victor Aguilar for their daily help and company. Finally, we are wholeheartedly thankful to Shirley Kliegel for making this trip possible.







**Thomas J. Ahrens, the Fletcher Jones Professor of Geophysics, Emeritus, at Caltech, died at his home in Pasadena on November 24. He was 74.**

An expert in the behavior and properties of rocks and minerals undergoing shock compression, Ahrens studied the dynamics of high-pressure materials inside Earth and other planets. His research also included planetary impacts and the formation of craters and planets.

“Tom was both a highly productive and broadly knowledgeable scientist and a dedicated mentor to dozens of students, postdocs, and visitors who now fill the ranks of mineral physics positions at universities around the world,” says Professor of Geology and Geochemistry Paul Asimow, who credits Ahrens as his most important mentor while Asimow was a junior faculty member at Caltech. Together, they ran the Lindhurst Laboratory of Experimental Geophysics, which Ahrens built in 1974 when the Seismological Laboratory moved to South Mudd. “Our relationship was symbiotic,” Asimow says. “Tom wanted to ensure beyond his retirement the ongoing productivity of the remarkable lab that he built, and I wanted to learn from his accumulated wisdom and to carry out experiments in a lab far beyond the scale and expense of anything I would have considered building from scratch.”

Some of Ahrens’s most important contributions, according to Asimow, were in developing experimental methods for measuring shock temperatures and the density of liquids at high pressure. When applied to iron, the first technique allowed researchers to determine the temperature structure of Earth’s core. The second method is so far the only way to measure the density of molten rocks that might form in Earth’s mantle at depths greater than a few hundred kilometers. Ahrens’s work has led to a basic understanding of how objects—such as meteorites and comets—carrying volatile materials smash into planets. His research has provided insight into the source and origin of water on Earth and into the environmental effects of meteorite collisions such as the one that struck Earth 65 million years ago and likely led to the extinction of the dinosaurs.

Born in Germany, Ahrens received his BS from the Massachusetts Institute of Technology in 1957, his MS from Caltech in 1958, and his PhD from Rensselaer Polytechnic Institute in 1962. He was a geophysicist with the Pan American Petroleum Corporation from 1958 to 1959, worked as a second lieutenant for the U.S. Army in the Ballistics Research Laboratory from 1959 to 1960, and was the head of the geophysics section in the Poulter Laboratory of the Stanford Research Institute from 1962 to 1967. He joined Caltech in 1967 as an associate professor of geophysics. He became professor of geophysics in 1976 and was the W. M. Keck Foundation Professor of Earth Sciences from 1996 to 2001; he was named the Fletcher Jones Professor of Geophysics in 2004 and became Jones Professor, Emeritus, in 2005.

Ahrens published more than 375 papers, held three U.S. patents, and received numerous honors and awards for his research. He was a member of the National Academy of Sciences and the American Academy of Arts and Sciences, and was a Foreign Associate of the Russian Academy of Sciences. He won the 1995 Arthur L. Day Medal of the Geological Society of America, the 1996 Harry H. Hess Medal of the American Geophysical Union, and the 1997 Barringer Medal of the Meteoritical Society, and he had an asteroid named after him.

He is survived by his wife, Earleen; children Earl, Eric, and Dawn; and grandchildren Greta, Violet, Jacqueline, and Samuel.

Research at the Division of Geological and Planetary Sciences includes studies that may range from the Earth's core, mantle, and crust, surface, ocean, and atmosphere to the outposts of the solar system.

Division faculty are leaders in earthquake studies; have determined the first reliable values of the age of the Earth, the moon, and meteorites; worked out the geological history of western North America; deciphered the record of the Earth's climate from studies of tree rings, marine sediments, and glaciers; perfected isotopic tracers and high-pressure laboratory techniques that indicate how magmas form on the Earth, the moon, and Mars; developed and applied geodetic tools for directly observing the motions of plate tectonics; and, using theoretical studies and data from spacecraft missions, have been largely responsible for our present understanding of the origin of planetary surfaces and atmospheres, satellites, rings, comets, asteroids, and the interplanetary plasma. The new Linde Center for Global Environmental Science will enrich the GPS Division's efforts to study the challenges of sustaining human, animal, and plant populations on our planet.

The Division of Geological and Planetary Sciences was established in 1926.

### About Research Options

#### Geology

Our educational and research programs in geology bring a range of field, remote-sensing, and laboratory-based approaches to understanding tectonic, petrologic, climatic, surficial, and paleontological processes and the history of Earth and its regions. In pursuit of field areas that preserve rich records of key geological events and processes, we can take advantage of the range of natural environments around us in Southern California or travel anywhere around the globe. We collaborate with the other options in the Division to develop new interdisciplinary tools for understanding the Earth.

#### Geobiology

Geobiologists study the role of life in shaping the chemical and physical characteristics of the Earth and, conversely, the environmental forces that have shaped the evolution and function of life. These questions span the range of geologic time, from the emergence and evolution of life on the earliest Earth to its role in shaping modern biogeochemical cycles. The tools employed by geobiologists at Caltech include sedimentology and stratigraphy, paleontology, paleomagnetism, organic and trace-element geochemistry, isotope geochemistry, molecular and cell biology.

#### Geochemistry

A wide variety of studies focus on the distribution of chemical elements in the Earth and the solar system in order to develop methods to date Earth and solar system processes, to discover and observe the chemical composition of terrestrial and extraterrestrial materials, and to study chemical reactions in the interior of the Earth as well as its surface and in the solar system outside of the Earth.

#### Geophysics

Large-scale computational facilities and easily accessible digital data are allowing traditional geophysical disciplines to be integrated to produce new insights into the dynamic processes of the Earth. Seismic activity in Southern California and the recent great earthquakes are stimulating studies into the physics of the earthquake process and their role in tectonics.

#### Planetary Science

Breadth in our understanding of Earth and its place in the cosmos is being gained by the comparative study of the other planets—their atmospheres, surfaces, and internal structures. The earliest solar and presolar history is being studied by seeking the connection between residual planetary materials and the physical processes within the solar nebula and the precursor interstellar medium.

#### Environmental Science and Engineering

Research addresses atmospheric dynamics, clouds and aerosols, air quality, and the dynamics of biogeochemical cycles and ecosystems. The methods employed in research projects include: computational modeling of chemical and physical processes on molecular to global scales; laboratory studies of fundamental chemical and biological processes; field studies of ocean geochemistry, soil microbiology, and atmospheric chemistry.

Division Chairman:  
Kenneth A. Farley

[www.gps.caltech.edu](http://www.gps.caltech.edu)

Division of Geological &  
Planetary Sciences  
1200 E. California Blvd  
MS 170-25  
Pasadena, CA 91125

(626)395-6111

Questions or comments about  
the newsletter?

Alumni news you would like to  
submit?

Please call or email them to the  
address below:

(626)395-6070

[gps-news@gps.caltech.edu](mailto:gps-news@gps.caltech.edu)

