# GEOLOGY at SMU

An occasional newsletter for alumni and friends: April 2005.

## John Walther finishes textbook

# Geochemistry for a New Generation

Professor John Walther's textbook, *Essentials of Geochemistry,* is now available from Bartlett and Jones. It is one of this publisher's new offerings in the upper division/graduate level geology textbook field.

Walther did tours of duty at Berkeley, where he completed his Ph.D. under this year's Harold Urey medal winner Professor Harold Helgesen, Yale and Northwestern before he came to SMU as the 2nd Matthews Chair holder. The faculty at each of these institutions have produced some of the best known textbooks in geology, geochemistry, geophysics, and petrology. After his arrival at SMU, conversations with then chairman A. Lee McAlester convinced John to write a textbook in geochemistry. While at Yale, McAlester was the editor and a contributor to the very impressive Prentice Hall Foundations in Earth Science Series.

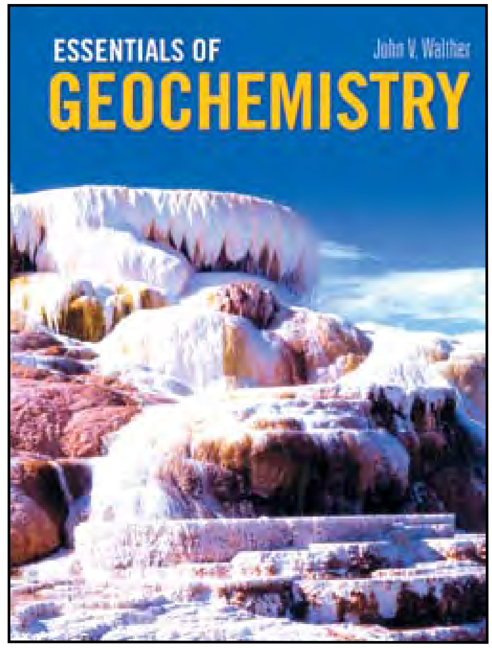
After more than six years of steady work later, the book is being used for the first time by this year's *Geochemistry* class. Students who confront this text will be exposed to a book with a very clear exposition, loaded with illustrative examples and numerous problem sets. This is a book aimed at those who want to apply thermodynamics to geochemistry and its application to the Earth and beyond.

**Matthews Chair Holder John Walther Research Interests**

- **Mineral solubilities at elevated temperatures and pressures**
- **Rates of mineral dissolution**
- **Mechanisms of surface reaction**
- **Fluid rock interactions in the crust**

The book covers the Earth starting with its aggregate chemical and physical state; this sets up an overview of thermodynamics. With this foundation in place, the chemistry of minerals and fluids sets the stage for geochemical analysis of important lithospheric processes. Beyond this, there are sections on the cosmic abundances of the elements, radioactivity and stable isotopes. The coverage also crosses over to a welcome discussion of organic geochemistry.

Available at the publisher's website is a downloadable copy of the computer program SUPCRIT92. Students test their new understanding of thermodynamics through computer calculations. The program enables the students to perform real world thermodynamic analysis of gases, fluids, solids, and aqueous species from approximately magmatic temperature to the freezing point of water and from 5,000 times atmospheric pressure to earth surface conditions.




**Cover of John Walther's new 700 page textbook shows tufa deposits from Yellowstone National Park. Carbon dioxide outgassing of discharging fluids drives precipitation of calcium carbonate overcoming the retrograde solubility of calcite.**

John can now devote more time to the laboratory where he measures rates of dissolution as a function of pH, temperature, pressure and composition. Surface charge distribution at the mineral-fluid interface helps explain changes in dissolution rates of aluminosilicates that occur as a function of pH. There is usually some pH where the rates pass through a minimum. For quartz and corundum, these minima occur at different pH; the trick is how to use the oxides to make predictions about the behavior of other more complex aluminosilicates. The goal: a better description of the Earth and the tools to understand other planetary objects where fluid- rock interaction is important.

### *Chairman's Report*

# Geochemistry + Plate tectonics = Geochemical dynamics

**By Robert T. Gregory**

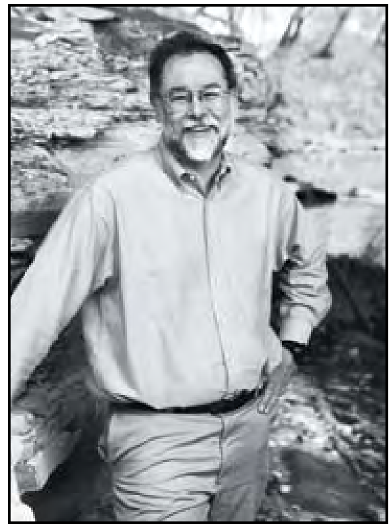


Photo by Hillsman B. Jackson

We are pleased to announce in the cover story the publication of Matthews Chair John Walther's new geochemistry textbook. Geochemistry is an important area for our department as it heads into the 21st century. Over half of the current faculty and their students make use of our various analytical laboratories.

Much of the work in our laboratories is devoted to pursuits relevant to climate change. Crayton Yapp's ground breaking work on the mineral goethite is the subject of our central story. Crayton's discovery of a small amount of carbon dioxide housed within the goethite crystal structure allows him to use carbon isotopes in addition to the carbon concentration to calculate pressures of carbon dioxide in the ancient atmosphere from paleosols.

In trying to explain differences between Earth and Venus, the late Harold Urey, credited with founding the field of stable isotope geochemistry, recognized the importance of water and carbon dioxide and their roles in chemical weathering and atmospheric composition. Carbon dioxide plus water provides acid for the dissolution of igneous or metamorphic minerals unstable under Earth surface conditions. He reasoned that the consumption of carbon dioxide by this process would prevent any planet with oceans from having a carbon dioxide-rich atmosphere. Urey reasoned that Venus must have lost an ocean of water early in its history resulting in an atmosphere with 90 bars $CO_2$ pressure.

On a planet with an ocean, the dissolved cations and the complementary bicarbonate anions are transported by rivers into the oceans where carbonate minerals and silica precipitate to deposit pelagic carbonate and siliceous oozes on the seafloor; this removes carbon dioxide from the atmosphere. Pelagic sediments riding on the top of the oceanic plates make their way to subduction zones where metamorphic decarbonation reactions release carbon dioxide that eventually makes its way back out to the atmosphere closing the cycle.

Dynamic systems with sources of a compound like carbon dioxide (outgassing and decarbonation reactions) and sinks (chemical weathering and sedimentation) tend toward steady states. $CO_2$ and $H_2O$ (both greenhouse gases) plus plate tectonics provide a "thermostatic control" on the climate of the Earth.

This modern view of the carbonate-silicate cycle pre-supposes the plate tectonic paradigm. Before plate tectonics, these processes were viewed as part of a one way differentiation of the Earth. John Walther's dissolution experiments have consequences for the rates of chemical weathering. It has been known for over a hundred years that weathering affects the flux of chemicals delivered to the oceans by rivers.

One of the first quantitative estimates for the age of the Earth was derived by measuring the salt content of the oceans and dividing it by the flux rate inferred from measurements on rivers. The age estimates using elements like sodium were on the order of 100's of millions of years; in agreement with Lord Kelvin's calculations based upon the cooling of the Earth. Of course the discovery of radioactivity and its application to geochronology early last century shattered the 100 million year old Earth idea forever.

Figuring out why the salt content of the oceans grossly underestimated the age of the Earth had to wait for the discoveries from the last half of the 20th century brought on by the plate tectonic revolution. Dredging and drilling of the seafloor (e.g. the Deep Sea Drilling Project, DSDP) yielded up hydrothermally altered basaltic rocks similar to those found in rock associations recognized in the Alps called ophiolites (see the panoramic view of Mt Cervino on page 7). The metamorphosed greenstones (and brownstones) called spilites were loaded with albite (sodium end member of plagioclase) replacing calcic plagioclase (Figure 1). This albite provided the missing sink for sodium delivered to the oceans through chemical weathering by the river flux. The discovery of "black smoker" hot springs at midocean ridges indicated that altered

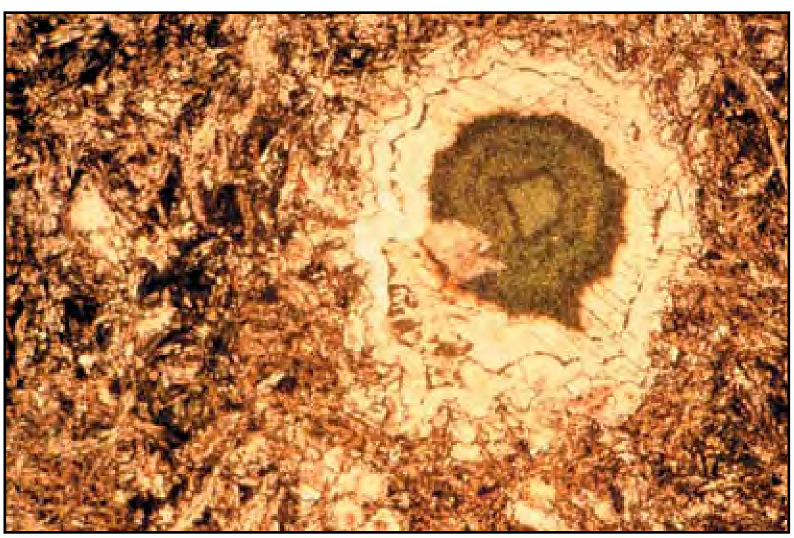


**Figure 1: Thin section of an Archean (>2.6 Gyr old) pillow lava from the Pilbara Block, Western Australia, exhibiting characteristic signs of seafloor hydrothermal alteration. The amygdule is lined with calcite (clear) and filled with chlorite (dark green). Albite replaces Ca-plagioclase laths. The hydrothermally altered greentone is a sink for seawater-derived Na, Mg, and carbonate.**

**Department of Geological Sciences**
**Southern Methodist University**
**P.O. Box 750395**
**Dallas, Texas 75275**
**214 768-2770; Fax 214 768-2701**
**E-mail: geol@.smu.edu**
**http://www.smu.edu/geology**

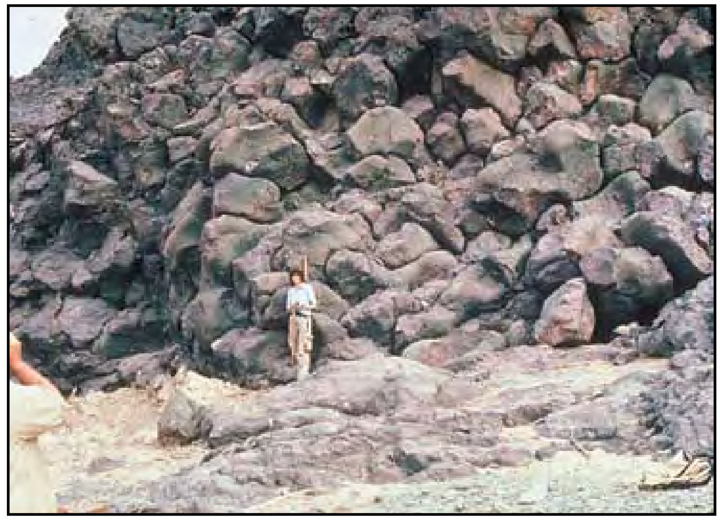
***Continued from Page 2***

samples were the result of normal processes occurring at seafloor spreading centers where mantle upwelling renews the crust.

Every element and isotope needed to be re-evaluated in the context of these newly discovered processes. In the 1970's, a graduate student at the University of Chicago, named Karlis Muehlenbachs, analyzed seafloor rocks for oxygen isotopes; he made a remarkable discovery. Rocks from the top part of the oceanic crust were enriched in $^{18}O$ (Figure 2) whereas rocks from deeper parts of the oceanic crust were depleted in $^{18}O$ relative to their original pristine mantle-derived magmatic isotope ratios.

The oceanic crust was both a source and a sink for heavy oxygen. Even though Muehlenbachs did not have a complete section of crust, he figured that the $^{18}O/^{16}O$ ratio of the ocean must be near steady state. By his estimates, the oxygen isotopic composition of seawater achieves a steady state when its $^{18}O/^{16}O$ ratio is about 6 per mil lower than the mantle. Plate tectonics holds the composition near steady state, a type of geochemical dynamics. In less than 5 years, studies of a complete section of ocean crust from the Samail ophiolite, Oman (Gregory & Taylor, 1981), provided confirmation of the Muehlenbachs hypothesis.

The geologic stability of the $^{18}O/^{16}O$ ratio of seawater enables stable isotope geologists to take advantage of this property to measure paleotemperatures, one of Urey's first tasks >50 years ago. Measurements on "proxies" (carbonates to ice cores) have elucidated the climate history of the Earth as never before.



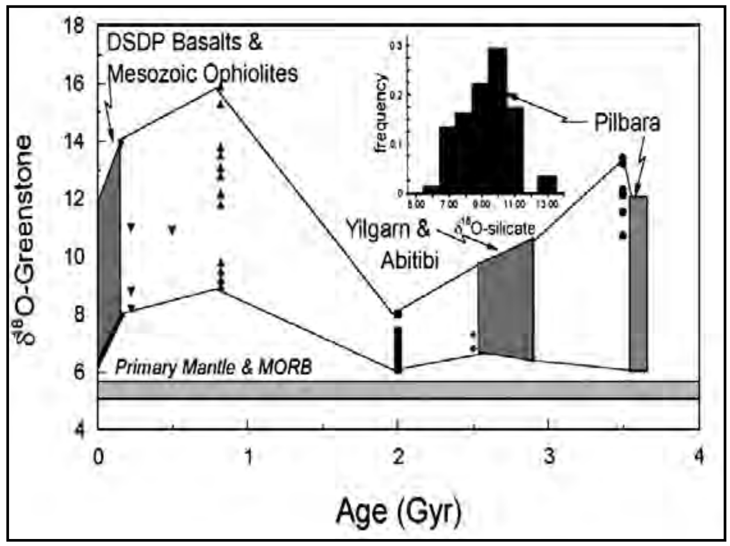



**Figure 2: Top--Pillow lavas from the Oman ophiolite exhibit the so-called "brown-to-green " facies seafloor hydrothermal metamorphism shown in Figure 1. Bottom: The deviation in the $^{18}O/^{16}O$ ratios referenced to standard modern seawater (the value "0" on the y-axis) of hydrothermally altered basalts plotted against their formation age. The consistent enrichment in $^{18}O/^{16}O$ ratio from +~5.7 to ~+10 of "greenstones" supports the Muehlenbachs hypothesis on the constancy of oxygen isotope composition of seawater.**

*2002 GSA Distinguished Service Award Winner*

## SMU Alumnus Professor David Dunn retiring from public life

David Dunn, (B.S., 1957; M.S. 1959), *Emeritus* Professor of Geosciences and former Dean of the School of Natural Sciences and Mathematics at the University of Texas at Dallas is closing down his UTD office to move to Green Valley, Arizona, south of Tucson.

Dr. Dunn most recently was the Vice-Chair of the Earth Science Task Force (ESTF) for the Texas State Board of Education. In 2002, the board appointed the task force as a result of efforts by a broad group of earth science professionals (including SMU and ISEM representatives) to get the teaching of earth science on an equal footing with chemistry, physics, and biology in Texas secondary schools.

Since 1999, earth science offerings are not explicitly part of the TAKS testing program resulting in their elimination as stand-alone course requirements for high school graduation. His commentary on the results of the efforts for reinstatement was published in *GSA Today*, December 2004. The reintroduction of earth science courses now stands as an unfunded mandate to be implemented later this decade.

For his lifelong exceptional service to the Geological Society of America, Dunn received its Distinguished Service Award in 2002.

See the full text of his commentary (Dunn & Roy, 2004) at *http://www.geosociety.org/sectdiv/southc/0412gt_commentary.pdf* .

**Top left: Goethite ooids separated from the Neda Formation (Fm.) ancient soil profile. Ooids ~ 650 μm to 750 μm were sorted by sieving.**
**Bottom left: Photomicrographs of ooids in the weathering profile of the Late Ordovician Neda Fm. The largest ooids are ~1mm**

# Natural Rust (α-FeOOH): $CO_2$

For Professor Crayton Yapp, the mineral goethite (iron hydroxide) represented the ideal candidate to measure the ancient meteoric water line (the linear relationship between the δ values of hydrogen and oxygen in natural surface waters) because it contained both hydrogen and oxygen. During stepwise dehydration experiments, necessary to extract the hydrogen isotopes, Crayton discovered that measureable amounts of carbon dioxide were actually sequestered within the goethite mineral structure. The solid state transformation of goethite (FeOOH) to hematite ($Fe_2O_3$) in vacuum yields water (and small mounts of $CO_2$).

$$2\ FeOOH = Fe_2O_3 + H_2O \quad (+\ CO_2)$$

The $CO_2$ in goethite is present as a component in a kind of interterstitial solid solution. This $CO_2$ component can be represented as $Fe(CO_3)OH$. Thus,

$$FeOOH + CO_2 = Fe(CO_3)OH$$

During heating, decarbonation was occurring along with dehydration. This carbon dioxide was only discovered because Crayton had the curiosity, and took the care, to analyze the contents of a second trap for reaction products other than water. A new paleoenvironmental probe was born.

Concentrations (mole fractions of carbon dioxide, X) and carbon isotope ratios ($\delta^{13}C$ values) are related to the concentration and the $\delta^{13}C$ value of $CO_2$ in the local environment at the time of crystallization. As a result, goethites (photos on the left) from natural paleosols (ancient soils) can yield information on the carbon dioxide in the Earth's ancient atmosphere. Remember that goethite, once formed, is relatively inert so that it faithfully records the conditions of its formation.

The concentrations and carbon isotope ratios of $CO_2$ in modern soils exhibit a characteristic pattern of variation with depth. When this pattern is found in ancient soils, it indicates that the concentration of atmospheric $CO_2$ can be determined. As

## *Institute for the Study of Earth & Man*

# Peter R. Vail: 2005 recipient of Hollis D. Hedberg

**By Louis L. Jacobs, President of I.S.E.M.**

Peter R. Vail, currently Professor *Emeritus* at Rice University will be honored on Wednesday, April 27, 2005, for his numerous and significant contributions to research in the energy industry and for his long-time commitment to education and academic research. He is the 2004-05 Hollis D. Hedberg Award winner.

Dr. Vail had a distinguished career at Exxon, mostly at what is now Exxon Production Research, where he directed a team that formulated and established "sequence stratigraphy" as a new paradigm for exploration. After leaving Exxon, he joined the faculty at Rice University where he was named the W. Maurice Ewing Professor. The Institute for the Study of Earth and Man honors the memory of Hollis D. Hedberg each year by presenting this award to those whose contributions have impacted the energy industry.

Originally trained as a sedimentologist/stratigrapher, Peter Vail made the connection between certain types of seismic reflectors and prominent physical boundaries within sedimentary successions. He extended some ideas of Sloss and Wheeler concerning the role of eustatic (world-wide) sealevel change in driving cyclical changes in depositional systems.

Using the unifying concept of sealevel change as a driving force, he noted that many prominent groupings of seismic reflectors record bedding planes or

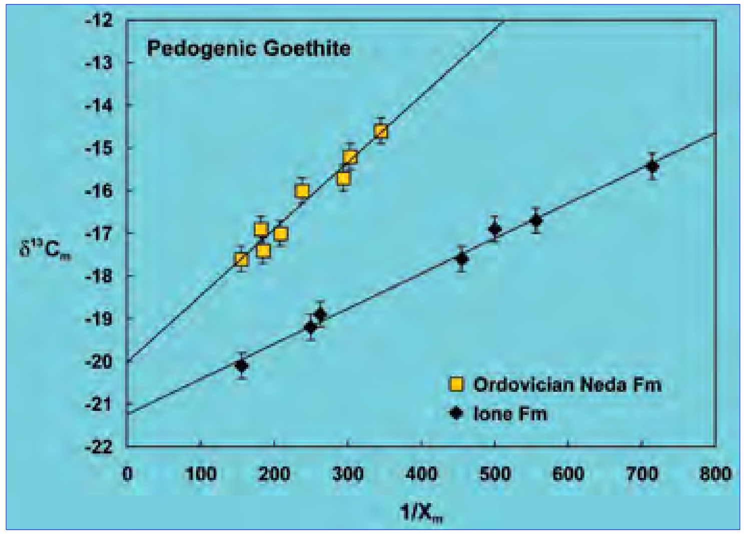
# in the Ancient Atmosphere

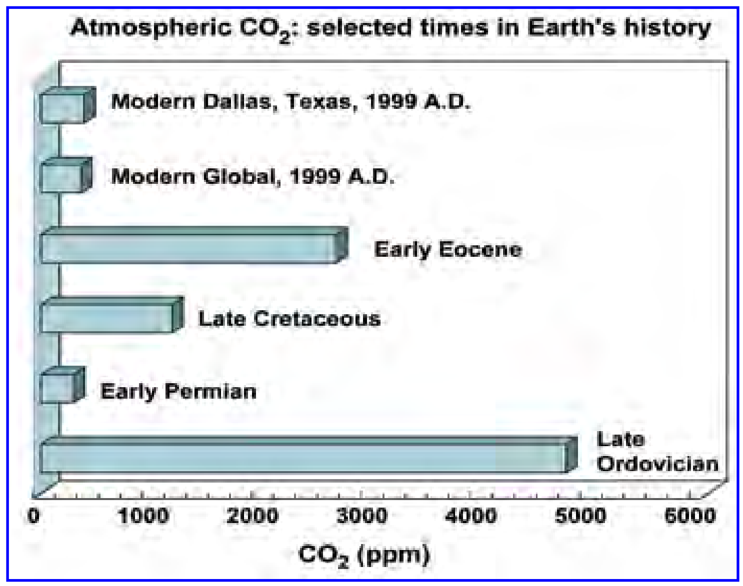
a function of depth, the measured parameters follow trajectories related to the diffusion in, and out, of the soil of atmospheric $CO_2$ and soil sourced $CO_2$, respectively. The soil gas $CO_2$ is derived from the oxidation of organic matter found in every soil. Such a pattern, for example, is preserved by the $Fe(CO_3)OH$ in the oolitic goethite of the ~ 440 million year old Neda Formation.

Ancient soil profile patterns of the type exhibited by modern soils translate to linear data arrays when $\delta^{13}C$ is plotted against 1/X. This is a common property of sets of paired concentrations and isotope ratios when diffusion or mixing is the physical process driving the measured variations. The slope of such a straight line is related to the concentration of $CO_2$ in the overlying atmosphere. The steeper the slope, the higher the concentration of atmospheric $CO_2$. The figure on the top right shows examples from the Late Ordovician Neda Fm. (Wisconsin) and the Early Eocene Ione Fm. (of north central California, ~50 Myr).

As shown by published data from gas inclusions in Antarctic ice, until the last ~100 years, the concentration of atmospheric $CO_2$ had not exceeded 300 ppmV (parts per million by volume) at any time in the past 420,000 years. However, at present, the $CO_2$ concentration in the global atmosphere is about 373 ppmV, and rising; perhaps reaching 600 ppmV this century.

Carbon dioxide is a "greenhouse" gas, and such increases raise important questions about the consequences for the Earth's future climate. Data from ancient samples of the mineral goethite indicate that Nature has already "run the experiment" at different times in Earth's history with $CO_2$ concentrations as high as 4800 ppm (greater than 15x present day values, bottom right). The paleoenvironmental consequences of such high concentrations of $CO_2$ are still being investigated.




**Top right: Goethite from two ancient weathering profiles. The slopes of the lines indicate atmospheric carbon dioxide concentrations of 4800 ppm, 440 million yrs ago and 2700 ppm, 52 million years ago; this compares with 370 ppm and rising for the modern atmosphere. Bottom right: Some ancient (from goethite) and modern global atmospheric $CO_2$ concentrations (ppm).**

# Award & Leighton Steward to be speaker

unconformities responding to changes in sealevel, e.g. surfaces of flooding or retreat. These observations were useful for exploration for the purposes of identifying the likely targets for oil and gas exploration.

The impact of "sequence stratigraphy" has gone beyond its use as an exploration tool. It is used to test ideas about paleogeography and paleoclimate from a more integrated and global perspective. It has stimulated work on the causes of sealevel change on all time scales.

With sealevel change underpinning the activities at this year's dinner and benefit, it is fitting that the after dinner presentation will be given by ISEM Board Chairman H. Leighton Steward (B.S. 1957; M.S. 1959). The presentation, "Loss of a National Treasure," will portray the dramatic decline in wetlands throughout the United States since the arrival of Christopher Columbus, with specific emphasis on the continuing shrinkage of the Mississippi River delta, the cause and significance of such shrinkage, and what is being done to slow or reverse such loss.

*If you are interested in attending or sponsoring a dinner table please contact Diana Vineyard, Institute for the Study of Earth & Man, at 214-768-2425. For more about the annual Hollis D. Hedberg Award, please visit :*
*http://www.smu.edu/isem/hedberg.htm*

# Hamilton Visiting Scholar: Professor Robert B Smith speaks on the geology and tectonics of Yellowstone Caldera

Robert Smith, Professor of Geology & Geophysics at University of Utah and lead author of the popular Oxford book, *Windows into the Earth: the Geologic Story of Yellowstone and Grand Teton National Parks,* presented three lectures as the 2005 Hamilton Visiting Scholar. The lectures on the general topic of the geology and geophysics of the western United States were centered around the discussion of Yellowstone National Park and its surroundings. His public lecture on the topic, "Yellowstone- Why is it Hot and Will it Explode?" was given to a full house

Dr. Smith began by recounting his experiences with the catastrophic Hebgen Lake earthquake that occurred just before midnight on August 17, 1959, with a 6.3 foreshock followed by a magnitude 7.5 earthquake. The earthquake caused vertical displacements as much as 7 meters, triggered landslides, seiches (large water waves) and killed 28 people. The event was one of those life changing moments that resulted in a career for Bob Smith studying the region to understand its geologic history and to assess its current risks. Why such an earthquake in the middle of the plate?- stress generated near the current position of an underlying mantle plume as North America moves over the hot spot.

The first of his two departmental lectures examined kinematic and dynamic models of western U.S. plate bounday deformation starting from the large scale to focus on the evolution of the Yellowstone Hot Spot track and how it affects the crust and upper mantle. His second departmental talk was an analysis of earthquake hazard assessment making use of post-seismic deformation determined from new high precision global positioning system (GPS) measurements.

The public lecture was a good introduction to the geology of the Yellowstone area. While the public thinks of Yellowstone as a National Park with superb wildlife, geologists know it as a gigantic volcano. Calderas, large closed depressions representing the collapse of the surface as a result from the loss of magma from below, reach 70 km in diameter in the Yellowstone area.

At Yellowstone, there are 3 big calderas, two of which are relatively intact. The biggest eruption occurred about 2 million years ago and produced at least 2,500 km$^3$ of magma, much of which was dispersed by the jet stream leaving identifiable ash deposits covering an area larger than the Lousiana Purchase and extending eastward to Missouri and Iowa. For comparison, the biggest recorded volcanic eruption in written history was that of Tambora, Indonesia, in 1815, with about 150 km$^3$ of magma erupted.

In answer to the question will it explode, Smith concluded that the odds were pretty slim, somewhere between 1 in 10,000 to 1 in several 100,000; still much better than winning the lottery. The odds of a disasterous earthquake are much greater (1 in a few hundreds), but still rather long odds by human standards; yet someone usually wins the lottery. Smith notes that the "long shot" odds for earthquakes and eruptions should not be confused with the false belief that they will never happen.

**Geological Sciences Hamilton Scholars**

| | | |
|---|---|---|
| 1997 | Carl Romney | SAIC |
| 1999 | Peter Marshall,O.B.E. | Blacknest, U.K. |
| 1999 | James O'Brian | Florida State University |
| 2000 | Chen Yun-tai | Inst. Geophysics, China |
| 2002 | Charles "Buck" Wilson | University of Alaska |
| 2004 | Robert R. Blanford | AFTAC |
| 2005 | Robert B. Smith | University of Utah |

Stephen Sprang, Xinlin Du, ThermoFinnigan engineer Bert Wolff and Bob Gregory check out the new (2nd in the U.S) Liquid Chromatography IsoLink interface put on to our existing isotope ratio mass spectrometer. The device enables the determination of the carbon isotope ratio of any water soluble carbon-bearing compound. Sprang and Xinlin Du (Hughes Medical Institute of UT Southwestern) will be using isotopically-labelled compounds to track and measure reaction kinetics of molecules of biochemical interest. The technique also shows great promise for organic stable isotope geochemistry.

# News of alumni, faculty, & friends

**Panorama of Mt Cervino (known as the Matterhorn from the Swiss side) taken from "Little Cervino." Mt. Cervino is part of the Dent Blanche Nappe consisting of eclogite facies rocks thrust over the Piedmont ophiolite nappe (a Tethyan ophiolite) in the foregound. The foliation and the axial planes of nappe structures are nearly flat lying. All of the rocks represent deep seafloor rocks that were subducted to perhaps 100 km depth and later exhumed to now reside on the top of the Alpine chain! Professor Bob Gregory was an invited delegate to the 32$^{nd}$ International Geologic Congress where he presented an overview of the geology of Oman ophiolite in a special session on Tethyan ophiolites. Ophiolites are remnants of oceanic plates (crust and mantle) found in mountain belts formed by the closing of ocean basins, in this case Tethys. Note the glacial lake (lower left corner) isolated by the recent rapid retreat of Alpine glaciers in the area, much of this the result of 20th century warming.**

The **3rd Golden Mustang Geologist Dinner** will be held at the SMU Faculty Club on May 12, 2005, celebrating the class of 1955. Each year, we invite all of the classes who took their degrees more than 48 years ago. Professor *Emeritus* Jim Brooks will once again be master of ceremonies.

The late **Claude Albritton, Jr. (B.S., 1933),** was honored (in memoriam) as an "SMU Scholar of Science" in an exhibition opened March 2nd, through April 15th, by Central University Libraries on display on the first floor of the Central University Library. **Professors Jim Brooks and David Blackwell (B.S., 1963**) spoke at the opening of the exhibit that centered around Jim Brook's tribute entitled, *Claude Albritton: Architect of the University.* John Finney, ISEM Librarian, organized Claude's exhibit.

**LaCretia Dickerson (B.S., 2004)**, winner of last year's undergraduate of the year award, has been working for Cirrus Associates. She splits her time between on-site work and her office in Richardson. She is doing site inspections and involved in environmental remediation projects.

**Vladimir Liakhovitch, (Ph.D., 1999)** has been working in Houston for Shell Global Solutions for the last year after a tour of duty at corporate headquarters in the Hague. His article, *Hydrogen and oxygen isotope constraints on the hydrothermal alteration of the Trinity Peridotite, Klamath Mountains, California*, appeared in *International Geology Review* and in a tribute to R.G. Coleman, part of *GSA's International Book Series*, Volume 8.

**Emily Mitchell (B.S., 2004),** a December graduate is enjoying her new position with Republic Energy; her internship was converted into a position in exploration.

**Former SMU Albritton Chair Peter Scholle and Dana Ulmer-Scholle (Ph.D., 1992)** received the annual Robert H. Dott, Sr., Memorial Award for best publication in geology by the American Associaton of Petroleum Geologists. They were honored for AAPG Memoir 77, *Color Guide to the Petrography of Carbonate Rocks: Grains, Textures, Porosity, Diagenesis.*

**Robin Wilcox (B.S., 2004)** will receive SMU Geological Sciences undergraduate of the year for 2004-05, funded by the **H. Grant Goodell (B.S., 1955)** Endowment in honor of the late Art Richards (see *Geology at SMU*, December 2001*). A December graduate, Robin is pursuing a M.S. degree at Lousiana State University where she is enrolled in the Applied Depositional Geosystems Masters Program.

**Dr. Mahmoud Khalili, Department of Geology, University of Isfahan, spent his study leave at SMU making use of our analytical facilities; here shown at the Variable Pressure Scanning Electron Microscope. In March, he presented a well-attended departmental seminar on the *Geology and Tectonics of Iran*.**

***Please share any career news and interesting photos with us for use in our newsletter. Contact Lisa Halliburton.***
****All prior issues of Geology at SMU can be found online at***

# Geological Sciences Faculty, Southern Methodist University

**David D. Blackwell**, Hamilton Professor, Ph.D., Harvard. Geothermal studies and their application to plate tectonics, energy resource estimates and geothermal exploration.

**James E. Brooks,** Professor *Emeritus,* Ph.D., University of Washington. Stratigraphy and Sedimentology

**Robert T. Gregory**, Professor, Chair, Ph.D., California Institute of Technology. Stable isotope geology and geochemistry, evolution of earth's fluid envelope and lithosphere.

**Eugene T. Herrin**, Shuler-Foscue Professor, Ph.D., Harvard. Theoretical and applied seismology, solid earth properties, computer analysis of geophysical data.

**Louis L. Jacobs**, Professor, Ph.D., University of Arizona. President of the Institute for the Study of Earth and Man. Vertebrate paleontology, evolution.

**Bonnie F. Jacobs**, Assistant Professor and Chair of the Environmental Science Program, Ph.D., Arizona. Paleobotany & palynology of the Cenozoic. bjacobs@smu.edu.

**A. Lee McAlester**, Professor, Ph.D., Yale University. Marine ecology-paleoecology, evolutionary theory, Paleozoic geology, petroleum geology.

**Jason R. McKenna,** Research Assistant Professor, Ph.D., Southern Methodist University. Thermal mechanical evolution of subduction zones.

**Brian W. Stump**, Albritton Professor, Ph.D., University of California, Berkeley. Seismology, seismic source theory, regional waves, seismic and infrasonic instrumentation.

**Neil J. Tabor,** Assistant Professor, Ph.D., University of California, Davis. Sedimentology, paleosols, stable isotopes and paleoclimate.

**John V. Walther**, Matthews Professor, Ph.D., University of California, Berkeley. Experimental and theoretical aqueous geochemistry, fluid-mineral interactions in the crust.

**Crayton J. Yapp**, Professor, Ph.D., California Institute of Technology. Stable isotope geochemistry applied to the study of paleoclimates, paleoatmospheres, and the hydrologic cycle.

## Adjunct Faculty

**Steve Bergman,** Adjunct Assistant Professor, Ph.D., Princeton University. Tectonics, petrology & geochronology .

**Anthony Fiorillo,** Research Associate Professor, Ph.D., Pennsylvania. Curator of Paleontology, Dallas Museum of Natural History. Vertebrate paleontology.

**Troy Stuckey**, Adjunct Assistant Professor, Ph.D., University of North Texas, EPA, Environmental Science and Policy.

**John Wagner**, Adjunct Assistant Professor, Ph.D., University of Texas, Dallas. Chief Geologist, Nexen Petroleum, USA.

**Alisa J. Winkler**, Research Associate Professor, Ph.D., Southern Methodist University, Mammalian paleontology, anatomy.

**Dale A. Winkler**, Adjunct Associate Professor and Director, Shuler Museum of Paleontology, Ph.D., University of Texas at Austin. Paleontology, paleoecology, stratigraphy.


**GEOLOGY FACULTY EMAIL ADDRESSES**

David Blackwell
blackwel@smu.edu
Robert Gregory
bgregory@smu.edu
Eugene Herrin
gloria@smu.edu
Louis L. Jacobs
jacobs@mail.smu.edu
Lee McAlester
mcaleste@smu.edu
Jason McKenna
jmckenna@smu.edu
Brian Stump
bstump@smu.edu
Neil J. Tabor
ntabor@smu.edu
John Walther
walther@smu.edu
Crayton J. Yapp
cjyapp@smu.edu



Southern Methodist University
Dedman College
Department of Geological Sciences
P.O. Box 750395
Dallas, Texas 75275-0395