GEOLOGY *at SMU*

A newsletter for alumni and friends - Fall 2003

Louis Jacobs & colleagues study early mammals

CT-scanning reveals hidden tooth

Professor Louis Jacobs looks for any opportunity to satisfy his passion for early mammals. His work extends SMU's effort in early mammals that are unique to north Texas. The late Bob Slaughter brought SMU recognition for his pioneering work in this area. Louis has a nose for good problems and is always looking for an edge by applying the best techniques of medical imaging.

Using the irreplaceable Shuler Museum collection (located in the basement of Heroy Hall) as material for teaching, Louis convinced Ph.D. candidate Yoshi Kobayashi to reexamine a mammal named after Bob Slaughter called *Slaughteria eruptens* (Figure 1) as part of a class that he and staff member Dr. Dale Winkler were teaching on new techniques in vertebrate paleontology.

Remember that mammals first appeared during the age of dinosaurs when being very small was a good survival strategy in a world crowded with giants. However, small vertebrates are not so easy to find so the record is still sparse; several species are defined on the basis of partial skeletons.

When analyzing family trees of fossils, paleontologists look for characteristic anatomical properties which unite one group with another, and in particular, they attempt to find the point in time where two evolutionary paths diverge.

For mammals, a divergence occurred between placental (e.g. "us") and marsupial (e.g. kangaroos) mammals some time in the Early Cretaceous (>100 Myr) and this is marked by distinctive patterns of tooth replacement. Different animal groups have distinctive strategies for replacing teeth either because of wear or because of changes brought on by maturing from juvenile to adult states.

Figure 1: Specimen of a *Slaughteria eruptens* jawbone prepared for ultra high resolution X-ray computer tomography (CT). X-ray CT enables the visualization of the internal structure of the jaw without sacrificing the sample. The fossil was named after SMU Professor Bob Slaughter and is housed within the Shuler Museum collection as part of its early mammal collection.

Modern placental mammals replace many "baby" teeth with adult teeth while modern marsupials only replace one premolar on each side of the jaw; premolars are teeth usually situated towards the front of the jaw and have morphologies consistent with uses other than the grinding function of molars. When Bob Slaughter originally examined *Slaughteria,* he concluded that the fossil jaw contained no replacement teeth and that all of the teeth were of an adult type. Another worker examined the same jaw and concluded that premolar and molar teeth were present; this is critical for determining the significance of replacement teeth for classification purposes. Both workers did not recognize any teeth in the process of eruption; the jaw bone blocked the view of the underlying root structure of the teeth.

Continued on Page 3

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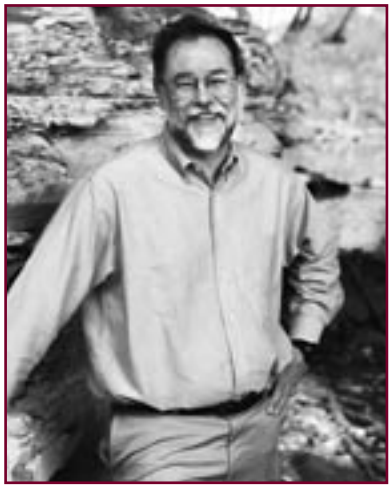
Chairman's Report

The rise of the new catastrophism: Lessons from the Colorado Plateau

By Robert Gregory



In this issue, we feature some of the work going on under the direction of Louis Jacobs. We also feature a commentary (page 6) by Louis on the biology textbook deliberations carried out by the Board of the Texas Education Agency. These hearings probably provide a hint at what is to come when the board considers implementation of the recommendations made in the "Report of the Earth Science Task Force" on the status of earth science education in the curriculum of the State of Texas (*see the Fall, 2001, newsletter for the current status of geology in Texas schools; it is archived at www.smu.edu/geology*).

A few years from now, the board will have to adopt an earth science book. Texas is a big market so any special interest group will attempt to cleanse the proposed textbook of any "threatening" ideas. Issues in the biology textbook debate revolved around the usual objections to Darwin. One thread that seems to come through in the style of the challenges is the idea that science is a collection of "facts" and that faith-based theories should be discussed along side of scientific ones.

Our frequent trips to the Colorado Plateau (p. 4-5) remind us of the old controversy between uniformitarianism and catastrophism that began as attempts to distance or reconcile geology from or with creation as portrayed in the account of *Genesis*. Careful observations of rock layers by French geologists showed too many "Biblical" floods and too many extinctions. Uniformitarism held sway and later influenced Darwin to propose his theory of evolution that required an unimagineably old Earth.

Planetary geology along with absolute dates on the cratered surfaces of the Moon showed that the evolution of planets is affected by a gradually declining number of collisions with asteriods or comets. Geologists now recognize the potential of non-uniformitarian processes to change dramatically the course of Earth history (e.g. see Claude Albritton's *Catastrophic Episodes in Earth History*, 1989). With the textbook controversies in mind, it is interesting to re-examine G.K. Gilbert's analysis of the origin of Meteor Crater. It is a good example of how "what you don't know that you don't know"can bite you while illustrating impecable fidelity to the scientific method as a process.

G.K. Gilbert was arguably the most famous of the original scientists appointed to the U.S. Geological Survey in 1875 under the direction of John Wesley Powell. Gilbert was one of the first proponents of an impact origin for the craters of the Moon. He was naturally very interested when in 1891, A.E. Foote reported to the National Academy of Science the discovery of iron of meteoritic origin associated with a crater of non-volcanic origin.

Since Foote made no conclusion with regard to the coincidence of the location of the crater and the occurrence of the meteoritic iron, Gilbert immediately proposed that the crater was the result of a collision of the Earth with a small celestial body so that the occurrence of the meteorites and the crater are explained by one hypothesis.

Gilbert dispatched one of his colleagues to the crater to make a field survey to test his idea. Upon examination of the crater, this geologist immediately thought of an additional hypothesis: the crater resulted from erosion of a laccolith, a type of igneous intrusion, that domed up the sedimentary rocks. The lack of any evidence of igneous rocks or contact metamorphism in the bottom of the crater quickly eliminated this idea. The geologist, named W.D. Johnson, then concluded that the best explanation was that the crater was the result of an explosion (probably from steam produced by nearby volcanoes); the occurrence of the meteoritic fragments was just a coincidence. This really bothered Gilbert who then decided to visit the site himself.

In order to test Johnson's idea, Gilbert recruited a magnetic field expert. If the crater were instead the result of an impact, Gilbert figured it should be elliptical (normal incidence would be fortuitous) and compass needles should be deflected by the buried mass of iron from the impactor. Gilbert and M. Baker of the U.S.G..S. measured the magnetic field along two orthogonal traverses and found no evidence of deflections of the type normally encountered with deposits of ironstone (they were counting on their experience prospecting for iron ore in Michigan). The intensity of the magnetic field did not vary along either of the traverses.

The geometry of the crater did not satisfy Gilbert's impact hypothesis. The ejecta around the crater could restore the hole. Based upon ballistic experiments (throwing clay balls into wet clay!), Gilbert thought an object about 500 meters across was necessary to produce the crater; it was all missing. In the absence of any supporting evidence for the impact hypothesis, he concluded that Johnson was correct in surmising that the crater was the result of a steam explosion. Gilbert cited examples of similar structures called maars that were described in Europe.

So where did Gilbert go wrong? A half a century later, geologists had a better idea about the physics of impacts. The incoming object only had to be a few 10's of meters across, not 500 m, and its velocity would have been greater than 11 km/sec, the escape velocity for the Earth, and not 10's of m/sec. Such an object makes a *circular* crater >10 times its size; the object itself is largely vaporized explaining the missing iron. Were Gilbert alive today, he would be pleased that his first idea was correct!

For more information see G..K. Gilbert (1896), Science 3, 1-13; Gilbert's article is reproduced in the series, Benchmark Papers in Geology v. 13, C.C. Albritton, Jr. (ed.).

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Shuler Museum specimen still yields results

SMU's Shuler Museum began with a collection of ice-age mammals and marine animals including plesiosaurs from the rocks of north Texas collected by Ellis Shuler, founder of the Department of Geological Sciences.

Continued from Page 1

As part of his class project, Yoshi Kobayashi got the machine time that allowed him to take X-ray pictures of the jaw bone in 36 micron intervals using a technique called ultra-high-resolution X-ray computer tomography (CT). They were able to make 3-dimensional stereographic images of the jaw. The X-ray scans enabled the reconstruction of the underlying structure of the teeth without destroying the priceless specimen (Figure 2). Their analysis revealed the existence of a simple permanent premolar in a pre-eruption position. While it doesn't sound like much, this is a critical piece of evidence when the whole specimen is smaller in size than a single dinosaur tooth. The new technique enabled the SMU group to make a new discovery.

The existence of a replacement tooth in a pre-eruption premolar position indicates a pattern of tooth replacement that could be a precursor to both of the styles now observed in modern placental and marsupial mammals. It suggests that the two lines diverged sometime after 110 Myr ago, the age of the specimen found in the Lower Cretaceous Antlers Formation of Texas. This work is an example of how teaching and research go together.

The application of the CT technique and the unexpected discovery stimulated new research to place *Slaughteria* on the evolutionary tree. Winkler and Jacobs think that a specimen identified as a separate species now represents the upper teeth that go with *Slaughteria*. With a bit of luck, Louis Jacobs and colleagues may get to find out what the whole animal looked like.

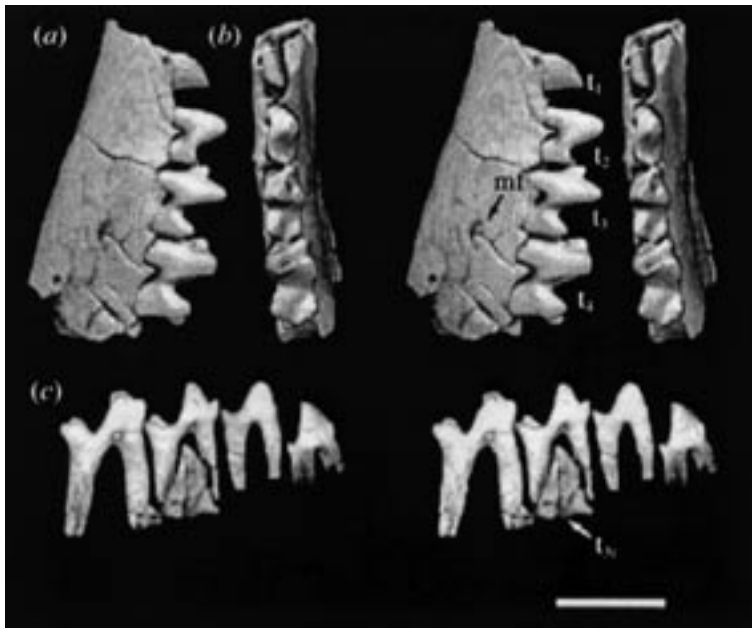


Figure 2: Stereographic view of X-ray computer tomographic (CT) images of the hidden structure of a early mammal's fossil jaw. The stereo pair in (c) reveals the existence of an adult tooth underlying t_3 (b) in a pre-eruption position, a key piece of evidence for understanding tooth replacement strategies that are diagnostic of vertebrate evolutionary trends. Scale bar is 2 mm.

For more information see Kobayashi, Winkler, & Jacobs, Proceedings of the Royal Society of London, available on line at their website. Kobayashi is due to defend his Ph.D. this December. The topic: a dinosaur bone bed in China.

2003 Graduate Degree Holders

New Ph.D.'s Bleamaster & Young studied plains of Venus

(Leslie F. Bleamaster III came to SMU to study planetary geology. Les, a former Navy Seal and currently, an active candidate for astronaut, has taken a postdoctoral research position at the Planetary Science Institute, University of Arizona, Tucson, where he hopes to get involved with NASA's Mars programs.

Duncan Young hails from New Zealand and acquired a taste for planetary geology while an undergraduate at University of Canterbury, South Island of New Zealand. Duncan is now a postdoctoral fellow at University of Minnesota, Duluth).

When Les Bleamaster and Duncan Young defended their Ph.D. dissertations this last spring, it, for the moment, marked the end of an era for the department that began with first Matthews Chair, Roger Phillips, and continued with the transformation of structural geologist Vicki Hansen (former SMU faculty member) into a full-time planetary geologist.

Phillips was a key player in NASA's Magellan program and recruited, then assistant professor Vicki Hansen, into the program, recognizing the need within the planetary community for geologists with earth-based credentials.

Bleamaster and Young produced quadrangle maps of Venus as the focal points of their dissertation work. Both concentrated on the volcanic lowlands of Venus, a very flat place dotted with numerous small volcanic shields and extensive lava flows associated with large circular structures called coronae.

Venus represents somewhat of an enigma in that, it has a statistically random distribution of craters. Crater counting is the key for developing a relative time scale for the solar system. Generally, older surfaces are saturated with craters whereas younger surfaces have fewer craters. The distribution of craters on the lowlands and highlands is statistically similar so that it is difficult to estimate the age of the surface to any precision. This suggested the hypothesis that the planet was either catastrophically resurfaced within the last half billion years or that there has been some major change in the tectonic regime.

Before the work of Bleamaster and Young, the volcanic lowlands had been lumped into a single map unit of presumed similar age. By using principles of earth-style mapping, they were able to show that each portion of the lowlands can be seen in detail to have a distinctive resurfacing history resulting from more uniformitarian processes.

Field Studies 2003: Trip to

For many years years now, either the "Rocks and Maps" or the "Introduction to Field Studies" classes have made the pilgrimage to the Colorado Plateau. Our alumni tell us that this practice extends back to the early days of the department; publications on Meteor Crater dating back to 1936 are credited to Claude Albritton, Jr.

The current trip consists of a marathon drive followed by stops beginning on the western side of the Rio Grande Rift (the Colorado Plateau is the western rift shoulder) leading to a hike into the Grand Canyon covering outcrops from the Permian Kaibab Limestone to the Cambrian Tapeats Sandstone. The students get to walk through rock formations that span some 250 million years of earth history, perhaps one of the best places to observe "uniformitarian" geology on the ground, gaps and all. At Plateau Point, they gaze down through the Precambrian rocks of the inner gorge to see the current level of the Colorado River just west of the confluence with Bright Angel Creek.

On the way to the Grand Canyon, we always make it a point to stop at Meteor Crater, Arizona, to see the world's best preserved example of an impact crater, one of the important data points for the new catastrophism. The first rate crater museum is operated by Meteor Crater Enterprises, a company that has roots in the original mining claims that staked out the crater as a potential iron ore mine. Enough drilling and exploration was completed to enable the claim holders to patent the claim and eventually get title to the property. It is currently worth far more as a tourist attraction than it ever was as an iron ore mine.

Sunset Crater, one of the youngest strombolian cinder cones in the continental United States with its spectacular *aa* lava flow, is a good place to camp. SP Crater, with its block lava flow, and Crater 160, an example of an explosive basaltic eruption that brought mantle nodules to the surface, are craters used by NASA

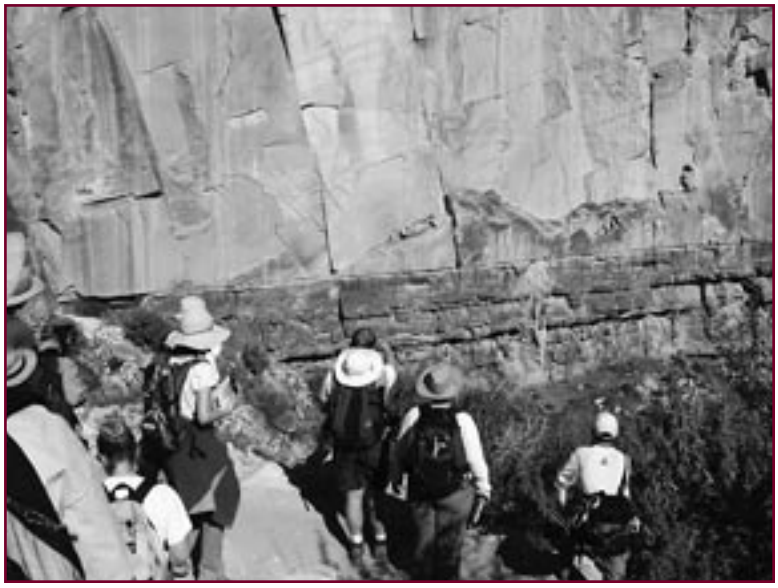
Colorado Plateau provides many geologic memories

in training exercises for remote sensing. These basaltic volcanoes are overshadowed by the presence of the San Francisco Peaks, a giant stratovolcano that in the recent geologic past experienced a Mt. St. Helens-style lateral blast eruption. Later on, during the trip, the students see the silicic pyroclastic deposits of the Superstition Mountains where geologists are still arguing about the locations of the vents for these gigantic eruptions.

In the Little Harquahala Mountains near Salome, Arizona, the group does some geologic mapping by following the contact between several slivers of overturned Paleozoic rocks and underlying Precambrian granitic rocks. The Paleozoic formations correlate with those on the Colorado Plateau and in the Grand Canyon. The Precambrian granodiorite and the fault contact with the metamorphosed Paleozoic rocks are intensely hydrothermally altered. Several gold mines were once active in the area.

On the way back to Dallas, the group travels through metamorphic core complex country via Phoenix and then follows the Salt River to see the economic fruits of the Salt River Project which supplies the water that makes the modern Phoenix metroplex possible. In the Salt River Gorge, the students get reacquainted with the unmetamorphosed Paleozoic section and get their first whiff of petroliferous limestone. Upon returning to the Colorado Plateau, a visit to the Petrified Forest National Park caps off a visit to the Triassic of the Painted Desert.

As a result of all of these stops, the students get to observe the geologic products of many different agents operating on many different time and spatial scales. They learn about life in the field.



Clockwise from top right: Postdoctoral fellow Neil Tabor points out ancient earth cracks penetrating the Hermit Shale filled with sand from the overlying Coconino cross-bedded sandstone. Petrified logs from Triassic rocks of the Colorado Plateau. Photomosaic of Meteor Crater (1.2 km in diameter) taken from the northeast corner of the rim. The view of the south rim from Plateau Point in the Grand Canyon. View of the Grand Canyon from the south rim.

Science Education

Design Curriculum Intelligently

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

It is school time again. The leaves of textbooks are turning, a foreshadowing that Fall is on the way. Disputes over curriculum and textbook content are as certain as the changing seasons. On September 10th the State Board of Education will be taking up the issue of evolution yet again.

I was asked to give a keynote address to science teachers in a certain Texas school district as part of their back-to-school activities because (I presume) I wrote the book *Lone Star Dinosaurs*. Teachers and students like dinosaurs and use them in science education. My instructions suggested "since the state no longer supports Earth Science toward graduation, we ask that your remarks illustrate how your work applies to science teachers 6-12."

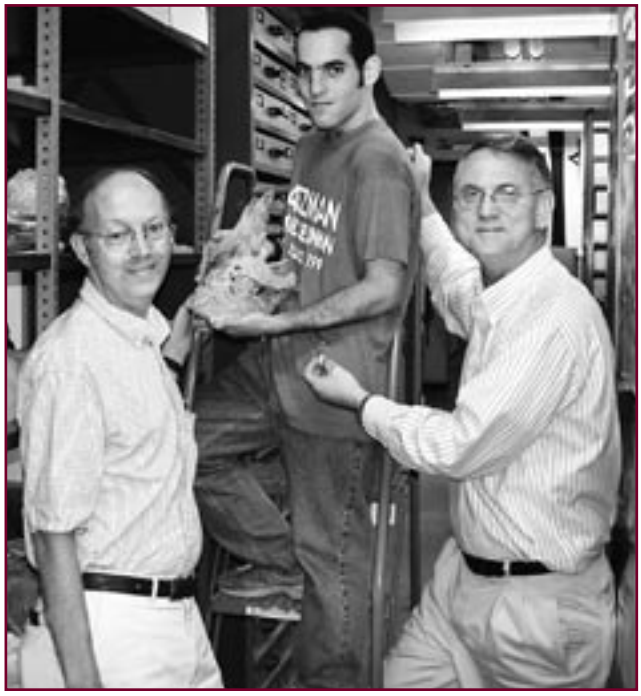
There are, arguably, three great unifying concepts in the natural sciences. The first removed Earth from the center of the solar system and replaced it with the sun. The second, plate tectonics, explains the functioning of Earth, the distribution of earthquakes and volcanoes, and the location of economic deposits. The third is evolution, which recognizes that all life on Earth is related, each species to the other, and that life changes through geologic time.

These concepts do not profess all knowledge of all things, but they have not been contradicted by subsequent observations. So here was my dilemma: As a paleontologist, my work rests on evolution, about which there is a textbook-content argument before the Texas Board of Education, and on Earth Science, which is not supported for graduation. In this case, two out of three strikes against science are bad; bad for education.

If the argument about evolution in textbooks were simply about science it would no longer come up, just as the celestial position of the sun does not, because the scientific community accepts evolution as well tested. But since Texas is the second largest market for textbooks, an antievolution campaign is waged here, complete with so-called experts from out-of-state coming to push their agenda. It takes the form of "intelligent design."

Even so, what a strong scientific community we have in Texas! Look at the research power of our universities and industry. Look at our hospitals. Look at our energy companies. Look at NASA. Medicine relies on molecular biology, which strengthens the concept of evolution and the continuity of life. The search for life on Mars is an investigation into the chemistry of life-forming processes, more relevant to Earth than outer space, because we know there is life on our planet, but we do not know of it anywhere else.

The wealth of Texas was built in large measure on oil, the distilled guts of past life, and Texas boasts one of the most highly qualified groups of Earth scientists anywhere. The physics, of radioactive decay is the same for nuclear power plants as it is for determining the age of Earth or for calculating the long-term hazards of radioactive wastes.



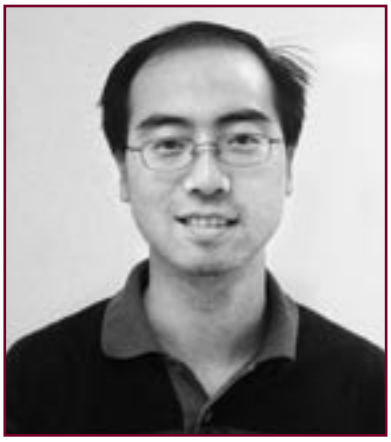
In the Shuler Museum, Dale Winkler, graduate student Peter Rose, and Louis Jacobs compare the size of an early mammal jaw (mounted on the sample holder shown on page 1) held by Louis with a dinosaur jaw held by Dale and Peter.

Still, for some there is really no immediate practical concern about where Earth is in the universe. It does not affect their lives on a daily basis to know that continents drift atop sliding tectonic plates. Nor is the reality of evolution a factor in day-to-day decision making. So they are free not to worry about unifying concepts, even though everyone benefits from and utilizes the results of that knowledge. In fact, the major objective of knowledge is to understand the big picture, how observations fit together, to satisfy curiosity and to use broader knowledge for the good of humanity. In that sense, there seems to be no limit as to how excellent a textbook or a curriculum can be. There is, however, a limit as to how bad a textbook can be and still be chosen for use.

Texas, because of its market share of textbook sales, is positioned to lead the country in educational quality. If we do not do that, if we opt for an agenda-driven curriculum, the question becomes how many extra hurdles do we wish to place in a student's path? A top-notch science curriculum would leave out the misrepresentations and misunderstandings of intelligent design, emphasize chemistry, physics, and biology, and include earth sciences equally. An understanding of those subjects makes for a scientifically literate public in a rapidly advancing technical age and prepares our students for their role in it.

This is the original version of an article published in an edited form by Dallas Morning News as "Don't let state hurt evolution," Monday, August 25, 2003

Three new graduate students join SMU



Weimin Feng, China

Weimin arrived in Dallas last August from China's Northwestern Shannxi province to pursue his Ph.D. in Geochemistry under the guidance of Professor Crayton Yapp. He achieved his BS and MS degrees from the University of Science and Technology of China (USTC) The focus of his research there was mainly high-temperature stable isotope geochemistry, whereas here at SMU he is working on low-temperature geochemistry. "Many things become easier for the low-temperature environment, but at the same time, many things become more complex - nature always treats you with great equality," he philosophizes. "Here at SMU, I will pull my focus from hundreds of millions of years ago to tens of millions of years ago, trying to resolve some paleoclimate problems. I also hope to do some fundamental research."

Weimin's retired parents live in his hometown, and he has a married sister with a young son. While Weimin wishes everyone could experience the amazing culture of China, the U.S. is much less crowded and the students at SMU have many more activities. Movies, music, soccer, and reading comics are Weimin's hobbies. It seems he has made a smooth transition to life in the United States, and with his positive, and friendly attitude, we know he will attain his goals.

Marie Renwald, New Mexico

Ask Marie what she likes best and the answer will be *explosions!* After receiving her Bachelor's degree from the University of Arizona in geophysics, and collaborating with the Ground-Based Nuclear Explosion Monitoring team at Los Alamos National Laboratory on verification research for the last two years, Marie is looking forward to broadening her experiences within the field by working towward her PhD with Drs. Stump and Herrin here at SMU as a National Science Foundation Graduate Research Fellow.

Experience was not the only thing Marie acquired while at Los Alamos last summer. She found an orphaned wild cottontail bunny, and dubbed him Sedgewick (the Seismic Bunny). Sedgewick eats organic field greens, stays in only the best hotels, and is scared of the outdoors.

Originally a creative writing and graphic design major, Marie became fascinated with geology after taking a course to fulfill her science requirement. Quilting as well as opera, photography, and golf are among her hobbies and interests. Marie is single and is also interested in education and outreach, (specifically seismology) in K-16 as well as opportunities afforded by EarthScope (an outreach program sponsored by the NSF.)

Marie is a delightful addition to the department, and we know her future will explode with opportunity.

Gayle Sullivan, Dallas

Lifelong learning is a concept that Gayle exemplifies. She has taught all ages in her career of 27 years (most recently at Dallas' private girls' Hockaday School). Gayle has taught science for the last 15 years. Attending workshops at the National Air and Space Museum during her time in the Washington DC area inspired her to study science. A special field trip for area science teachers organized by Bob Gregory (also her advisor) sparked her interest in pursuing a Master's in Geology at SMU after moving to Plano.

While raising her two daughters, Gayle was on the move due to her husband's job. She succeeded in making a place her herself in four states, and completed her Master's degree in Educational Psychology while teaching in New York state.

When her busy schedule permits, Gayle enjoys her "natual scientist" grandson, Patrick, reading, walking/jogging, bike riding, and tennis. The family enjoys the beach and visiting back east during the holidays.

We're confident that the department will benefit from Gayle's love of learning and experience while she enjoys "doing real science."

Please note: Rongsheng Yang (M.S., Lanzhou Institute of Geology, Chinese Academy of Sciences) was to be our 4th graduate student but, despite having excellent credentials, was unable to obtain an entry visa from the US Embassy in Beijing.

Geological Sciences Faculty, Southern Methodist University

David D. Blackwell, Hamilton Professor, Ph.D., Harvard. Geothermal studies and their application to plate tectonics, especially of the western United States; energy resource estimates and geothermal exploration.

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 Chairman of the Environmental Science Program, Ph.D., University of Arizona. Paleobotany of Tertiary deposits of Africa, application of pollen analysis to Cenozoic geological and environmental problems. bjacobs@smu.edu.

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

Jason R. McKenna, Visiting Assistant Professor, Ph.D., Southern Methodist University. Thermal mechanical evolution of subduction zones; thermal modeling of petroleum and geothermal systems.

Brian W. Stump, Albritton Professor, Ph.D., University of California, Berkeley. Seismology, earthquake and explosion source theory, regional wave propagation, seismic and infrasonic instrumentation and data acquisition; mine-related seismicity.

John V. Walther, Matthews Professor, Ph.D., University of California, Berkeley. Experimental and theoretical aqueous geochemistry, fluid-mineral surface interactions, kinetics of dissolution, and mineral solubilities as a function of temperature, pressure and solution composition.

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 of sedimentary basins, surface processes, volcanology, geochronology and petrology.

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

Alisa J. Winkler, Research Associate Professor, Ph.D., S .M.U. Mammalian paleontology, anatomy.

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

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