# austin geological society

# bulletin

volume 3

2006-2007

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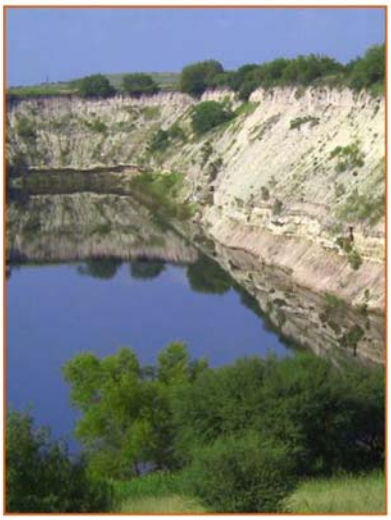

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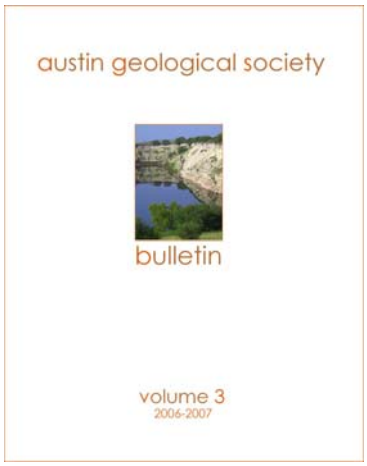
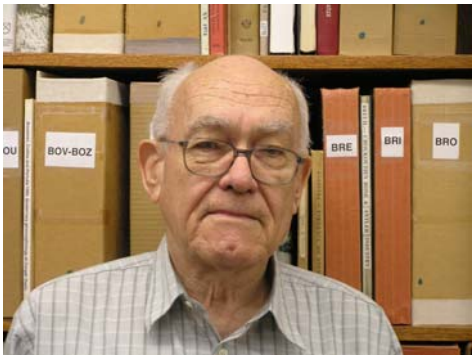



*Image on preceding page:*
*The Sickenius Mine in the Karnes Uranium District (photo by John Brandt).*




# note from the president

This past year has been a good one for the Austin Geological Society. Our membership continues to grow, now standing at well over 100, and attendance at meetings is up. The field trip to the uranium mine in Karnes County was a great success thanks to the leaders, Al Cherepon and Bill Galloway. This was the last chance to see the mine and its exposed stratigraphy before it is reclaimed.

Our efforts to expand participation by the academic community continued. We were successful in increasing student participation thanks to the efforts of Sarah Davidson, Chair of the Student Liaison Committee, and Clark Wilson, chair of the Department of Geological Sciences, who made available no cost transportation for students from campus to the Pickle Research Campus.

The Society continued to be active in promoting Earth Science education in high schools and middle schools thanks to the efforts of John Mikels, Chair of the Education Committee. Bob Bluntzer, Scott Tiller, Linda Ruiz McCall, and John Mikels served as judges for the Austin Regional Science Festival in February of 2007. Several of the students presented their projects at the March poster session. The ingenuity shown by these students was very impressive and bodes well for the future of our science.

The Bulletin is now entering its third year thanks to the efforts of Robert Mace, Brian Hunt, and others. This is a place for people to contribute papers on geology, and I urge all members to consider submitting the results of their research to the Bulletin.

We continue to acknowledge the support of the Bureau of Economic Geology, especially Scott Tinker and Wanda La Plant, in allowing the Society to hold our meetings at the Bureau's facility at Pickle Research Campus. Thanks are also due to Amanda Masterson for keeping the Bureau's publications office open during our meetings.

Finally, I would like to thank the Society for giving me this opportunity to serve as president. It has been a pleasure to work with so many interesting and dedicated individuals.

Ernest Lundelius Jr. 2006–2007 AGS President

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# note from the editor

Because I'm so forgetful, I write nearly everything down. I have lists for shopping, lists of to do's for home and work and, believe it or not, lists of lists. This forgetfulness and urge to write things down extends to other parts of my life as well, both professional and personal. At work, if I have to learn about a topic or issue, I like to document what I learned. Invariably, the facts in my head become muddled over time. If I've written the facts down, I can quickly review what I learned the first time. Furthermore, the process of writing forces me to think more clearly about a topic, to see angles I hadn't seen before, and to better understand the issue or issues at hand. At home, I've started writing down the various anecdotes I've bored people with for years. On the negative side, my anecdotes, like fine wines, won't improve as the years pass by since they will now be frozen in time. Nonetheless, it feels good to get them down on paper—and I can always enhance the truth in them later!

One of my mantras is "If it's not written down, it doesn't exist." This is certainly true in a scientific field such as ours. One can do research to understand, but if it isn't written down and—just as important—accessible to other researchers, it simply doesn't exist. That's why it's important to write stuff down. If you don't, it's lost forever. This also applies in personal relationships and interactions. If everybody heard and remembered the same thing, there would be no need for contracts. Words are understanding—something that can be revisited and redevoured.

Fortunately, we've found some folks willing to write for you the results of their studies and some colorful recollections of Austin's geologic past. For this we, the editorial staff and society, are grateful. Current and future readers are and will be grateful as well.

Please: share your words!

Robert E. Mace, Editor

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# austin geological society

## bulletin, volume 3, 2006-2007

**mission:** The mission of the *Austin Geological Society Bulletin* is to (1) summarize the previous year's activities of the Society and (2) publish technical papers, comments, and notes concerning the natural sciences of Central Texas.



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**information to authors:** The editors of the *Austin Geological Society Bulletin* invite contributions relating to the natural sciences of Central Texas in the form of technical papers and discussions. If you would like to submit to the bulletin, please see the instructions to authors at the end of this document. All submissions should be sent to the editor in digital format to editor@austingeosoc.org.

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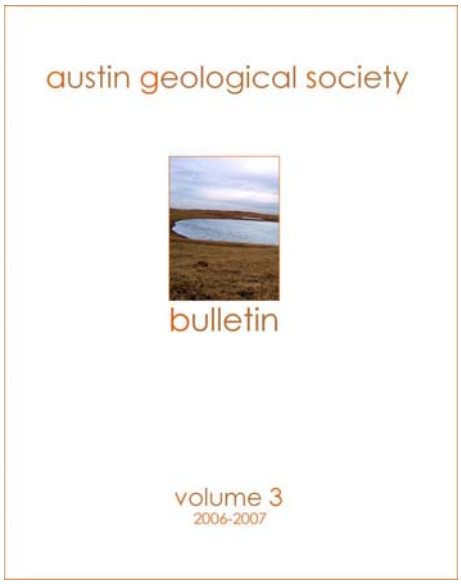


*Cover photo: The reclaimed Kellner Mine in the Karnes Uranium District (photo by Alan Cherepon).*

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austin geological society

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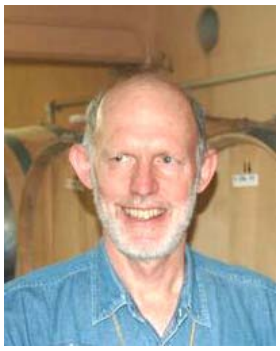
# news from the society

## Dr. Bridget Scanlon chosen as the 2007 Birdsall-Dreiss Lecturer

Bridget Scanlon of The University of Texas at Austin has been selected as the 2007 Birdsall-Dreiss Distinguished Lecturer sponsored by the Geological Society of America Hydrogeology Division. At the request of institutions, she has been presenting one of two lectures for audiences interested in broad aspects of water resources. Bridget has been touring the country and the world speaking on "Implications of Climate Variability for Groundwater Resources and Waste Disposal in Semiarid Regions—A Look at Ecological Controls from Annual to Millennial Timescales" and "Impacts of Changing Land Use on Subsurface Water Resources in Semiarid Regions." Bridget Scanlon received a B.S. in Geology at Trinity College, Dublin (Ireland), an M.S. at the University of Alabama, and a Ph.D. from the University of Kentucky (Lexington). She is currently a Senior Research Scientist at the Bureau of Economic Geology, Jackson School of Geosciences. The primary objective of her research group is to assess sustainability issues with respect to water resources, within the context of climate variability and land-use change. Studies integrate physical, chemical, and isotopic analyses and numerical modeling. Much of her research focuses on groundwater recharge in semiarid regions in natural and cultivated ecosystems. Bridget Scanlon has taught Vadose Zone Hydrology at the Department of Geological Sciences and Civil Engineering at The University of Texas at Austin. She participated in focus groups on global recharge issues within the International Atomic Energy Agency. She served on National Academy of Sciences committees on radioactive waste disposal and is currently serving on the Integrated Observations on Hydrologic Sciences committee. (*text modified from Bureau of Economic Geology's Web site*)

## Doug Ratcliff awarded honorary membership by the Gulf Coast Association of Geological Societies

Doug Ratcliff received honorary membership by the Gulf Coast Association of Geological Societies at the 2006 meeting in Lafayette, Louisiana. Ratcliff earned a bachelor's degree in political science from The University of Texas at Austin, completed an MBA at St. Edward's University while working full time at the Bureau of Economic Geology, and also earned another bachelor's degree in geology from The University of Texas at Austin. He served as the General Chairman of the 2002 Gulf Coast Association of Geological Societies annual convention in Austin and has long supported American Association of Petroleum Geologists and Austin Geological Society professional activities. (*text and photo modified from Bureau of Economic Geology's Web site*)



## Chock Woodruff awarded the distinguished service award by the Gulf Coast Association of Geological Societies

Charles M. Woodruff Jr. was awarded the distinguished service award by the by the Gulf Coast Association of Geological Societies at the 2006 meeting in Lafayette, Louisiana. Chock has been a solid presence in the Austin Geological Society for many years, coordinating many of the field trips we've had. Charles M. Woodruff, Jr. received his B.A. and M.S. degrees in geology from Vanderbilt University and his Ph.D. from The University of Texas at Austin. He worked as a research geologist for the university from 1972 until 1983. Since 1983, he has been an independent consulting geologist, and since 2001 he has been a Senior Lecturer in the Department of Civil Engineering at the university.

# Jim Sansom awarded Honorary Membership by the Society

Jim Sansom was awarded an honorary membership by the Austin Geological Society in recognition of his outstanding service and contributions to the society. Jim was a charter member of the society. Jim received his B.S. in geology from The University of Texas at Austin in 1963 and has worked for the Texas Department of Transportation (1963–1965), Texas Water Development Board (1965–1978), the Railroad Commission of Texas (1980–1989), and his own company, Sansom Geological (since 1989). His service to the society includes being the secretary (1965–1966), vice president (1966–1967), and president (1972–1973). More recently, he has served on the membership committee (2006–2007). The society is grateful for his involvement in the society, his expertise, and his enthusiasm in the society. (*photo: Jim Sansom on left, Brian Hunt on right*)

# Robert Mace awarded the Technology Award by the National Ground Water Association

Robert E. Mace, Groundwater Resources Director for the Texas Water Development Board's Office of Planning, is the recipient of the National Ground Water Association's 2006 Technology Award. Robert was recognized for his work in educating and informing the citizens of Texas about current groundwater situations and the future outlook of groundwater through the use of groundwater availability models. The Technology Award is presented to a person who has made a major contribution to the groundwater industry in the development of ideas, tools, and equipment; techniques of well construction; exemplary service to coworkers throughout the industry in sharing these developments; and performing service for the protection of groundwater resources and the consuming public. Dr. Mace received both his bachelor's and master's degree from the New Mexico Institute of Mining and Technology and his Ph.D. from the University of Texas at Austin. A licensed professional geoscientist in the State of Texas, Mace is a member of many professional organizations including National Ground Water Association, the Geological Society of America, and the Austin Geological Society. Mace is a two-time recipient of the Barton Springs/Edwards Aquifer Conservation District's Research Conservation Award (2002 and 2004), as well as the recipient of the New Mexico Tech Service Award in 1989. During his tenure with the Texas Water Development Board, Dr. Mace has led several conferences on behalf of the agency including, the Aquifers of West Texas (2001), Aquifers of the Edwards Plateau (2004), 100 Years of the Rule of Capture (2004) and the Aquifers of the Gulf Coast (2006).


# Brian Hunt develops geologic display for the Mason Square Museum


The Mason Square Museum opened on April 7, 2007, featuring geologic and paleontologic exhibits among historical and archeological displays. Mason County is within the Llano Uplift of central Texas and contains a long, diverse, and interesting geologic history described in four panels. In addition, the museum contains some wonderful paleontological and mineral specimens including the largest topaz gem of Texas, returned from the Smithsonian in Washington! Austin Geological Society member Brian B. Hunt developed the content and layout for the geology panels.

# AGS Splashes at Zilker Park

AGS members Sigrid Clift, Jim Sansom, Jimmie Russell, Ernie Lundelius, and John Mikels contributed their time and talents at the September 2006 "Splash Exhibit" at Zilker Park. This annual, City of Austin sponsored educational event is for Austin area elementary and middle school students and focuses on earth science and water resources. The AGS members ran several of the active exhibits at the event, entertaining and educating Austin area youth.

# agency news

## Barton Springs/Edwards Aquifer Conservation District

The district and much of Texas experienced a severe drought that began in May 2005. By the end of 2006 water levels in the Lovelady Well and flow at Barton Springs were both below their critical stage drought triggers (Figure 1). The district declared a critical stage drought on September 27, 2006, for the first time since it began making drought declarations in 1991. This level of drought mandated a 30 percent reduction in groundwater pumping from permittees. The drought ended in March 2007 after above-average rainfall in January and March.

On April 12, 2007, the district amended its rules to more effectively manage and preserve the groundwater resources of the district for its historic permittees and users during drought conditions. A limit for pumping water from the Edwards (and upper Trinity) aquifers during critical drought stage was established at 8.5 cubic feet per second on an average annual basis, which is the equivalent of about 2.0 billion gallons, or 6,150 acre-feet, per year.

The Texas Legislature passed Senate Bill 747, which is designed to allow the district to deal more effectively with extreme drought management. It raises the water use fee on newly requested conditional groundwater to be more in line with the costs of raw (untreated, undelivered) surface water, and it prescribes greater curtailment of various classes of water under specified drought conditions.

On June 7, 2006, district staff was notified by the Texas Commission on Environmental Quality that the district had been awarded a U.S. Environmental Protection Agency nonpoint source pollution 319(h) grant to enhance the quality of water recharging the aquifer. Using past 319(h) grant funds, the district installed a BMP (best management practice) structure over Antioch Cave on Onion Creek in 1997. The current grant plan calls for upgrading the BMP at Antioch and installation of a BMP over another recharge feature within the district. Continuous water quality monitoring network systems will be installed at each BMP in addition to automated systems to open and close valves that will minimize the amount of sediment and pollutant-laden stormwater from entering the aquifer at these recharge features.

For further information please contact the district at (512) 282-8441, bseacd@bseacd.org or visit the district's Web site at http://www.bseacd.org/.

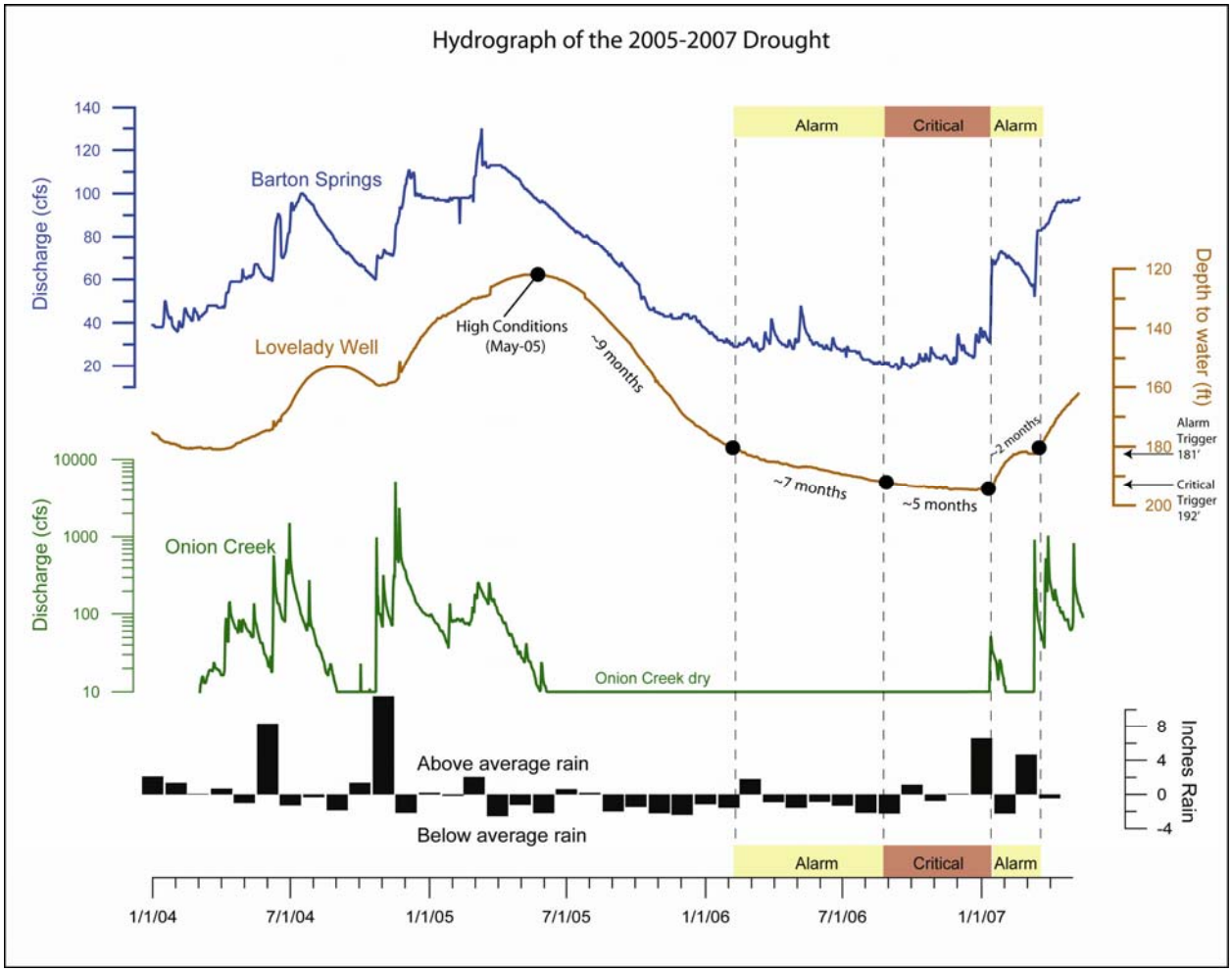



**Figure 1. Hydrograph of the 2005–2007 drought. Barton Springs and the Lovelady Well are the indicators for drought for the Barton Springs/Edwards Aquifer Conservation District.**

## Texas Water Development Board

The biggest news this year from the Texas Water Development Board was the release of the 2007 State Water Plan in early January. The document, which can be downloaded here: http://www.twdb.state.tx.us/publications/reports/State_Water_Plan/2007/2007StateWaterPlan/2007StateWaterPlan.htm, presents a plan for meeting most of Texas' water demands through 2060 as well as a comprehensive chapter on the groundwater resources of the state. The plan includes revisions to the boundaries of several of the state's major and minor aquifers.

## Lower Colorado River Authority

As part of its Highland Lakes Watershed Ordinance program, the Lower Colorado River Authority has implemented a set of quarry and mine regulations addressing water quality of stormwater and groundwater. These ordinance provisions were devised in a stakeholder process including the mining industry and environmental interests. The regulations were put into effect

on March 1, 2007, and apply to areas in Travis, Burnet, and Llano counties that drain to the Highland Lakes operated by the authority.

The Lower Colorado River Authority has created several watershed assessment posters for use by developers, agencies and the public in areas facing land development. The newest posters cover the watersheds of Northwest Travis County, Hamilton Pool, and Heinz Branch-Westcave Preserve.

Using information from published maps, reports and public data sets, authority staff created and donated a geologic cross section to the "Falls on the Colorado Museum" in Marble Falls, Texas. The cross section is an interpretation of geology beneath the waters of Lake Marble Falls.

Progress on the LCRA/SAWS Water Project has included calibration and refinement of a detailed groundwater model of the Gulf Coast Aquifer. The Texas Water Development Board, local groundwater conservation districts, and a scientific review panel have been kept informed on the project. For the latest, see http://www.lcra.org/lswp/index.html.


*Sigrid Clift makes sugar karst at Splash! at Zilker Park.*

# about the technical content

The technical content in the Bulletin consists of abstracts or extended abstracts for presentations, summaries of the field trips, technical papers, and notes.

## presentation

The Austin Geological Society hosts technical presentations from invited speakers concerning the natural sciences. We publish an abstract in the Society's newsletter and allow for an extended abstract in the Bulletin.

## posters

The Austin Geological Society hosts a poster session each spring. Presenters can submit an abstract concerning their poster topic. This year, we also received abstracts from young scientists from local schools who participated in the regional science fair.

## field trip

The Austin Geological Society tries to have at least one field trip per year. The summary included here provides an overview of this year's trip. Interested readers are encouraged to purchase the guide book for additional information and details.

## technical paper

The Bulletin accepts technical papers for publication provided that the papers meet technical and editorial requirements.

## note

The Bulletin also accepts notes, which may be technical or anecdotal.

presentation

**august 28, 2006, bureau of economic geology**

# Geo-Ethics

Scott W. Tinker
*Bureau of Economic Geology*

Accusations of business ethics violations seem to dominate headlines. Were these companies unguided by ethics polices? Quite the contrary—but they were seemingly unguided by ethical leadership. Although leaders influence the financial, strategic, and political aspects of a company, perhaps nowhere is the impact of leadership felt more strongly than in the ethics arena. Ethical companies depend on ethical leaders.

Some ethical situations are straightforward and can be guided by rules, laws, and policies. However, many situations are "neither wholly right nor wholly wrong" and introduce difficult dilemmas having justifiable alternatives and significant consequences. The business ethics gray zone is made more complicated by the complex global condition in which laws vary by country and ethics vary by culture.

Is it possible to frame an approach for ethical decision making in a world where no society, culture, or religion owns the ethical high ground? Laws and rules result from historical precedence and as such serve as well-founded guidelines for business decision making. But laws and rules should not be used to provide protective legal cover for corporations to do the wrong thing.

Corporations do not make ethical decisions; individuals do. Can an approach that targets the individual achieve results that exceed the ethical capacity of the organization? Several case examples provide a framework to explore ethical decision making, with a focus on a few basic tenets of individual interaction—honor your promises; consider the spirit of the law, recognize the situational context, reflect before deciding, compromise within personal limits, accept responsibility, and follow the Golden Rule.

presentation

**october 2, 2006, bureau of economic geology**

# Mysteries of Sistema Zacaton: A connection between outer space, caves, water, and microbes

Marcus Gary
*U. S. Geological Survey*

Sistema Zacaton, a hydrothermal karst area in northeastern Mexico and site of the deepest water-filled sinkhole in the world, will be the test site for the DEPTHX probe. This unmanned, autonomous vehicle will explore the underwater realm of the Zacaton sinkhole and search for microbial life. The impetus for this NASA funded project is to begin development of an instrument that would someday look for extraterrestrial life on Europa, the ice-covered moon of Jupiter.

presentation

**november 6, 2006, bureau of economic geology**

# Global Energy in the 21st Century

William L. Fisher
*Jackson School of Geosciences,*
*The University of Texas at Austin*

Fundamental trends in the mix of energy fuels, efficiencies in energy development and use, population, and the global economy have been established historically and provide a reasonably certain trajectory of the future. Many will impact the near term.

The long-term trend in efficiencies is notable. In exploration and development it has resulted in relatively low-cost supplies extracted from a resource base that, while ample, is progressively more challenging. In energy use per unit of economic product there has been a long-term decline that will continue and likely accelerate and will moderate the demands from a global economy that will likely grow an average of 3 percent annually, real term. The pace of global population increase is slowing and may well peak at under 10 billion people at mid-century.

The mix of energy fuels, as measured by percent of total energy used, has shown long term progress from hydrogen-poor to hydrogen-rich fuels. Wood long peaked as the world's major energy source; coal peaked 1,000 years ago, oil 25 years ago as natural gas comes to the forefront and brings us to the threshold of the methane economy. Not only the fuel of choice—

clean and, most important, efficient—but the likely source of hydrogen for the fuel cell as we proceed to the full hydrogen economy coming in place 50 or so years from now. Mid-century production of hydrogen will likely be from either nuclear or solar energy.

Translated into implied volumes of demand over the next half century, coal as a directly burned fuel will amount to no more than 150 billion tons (less than half of historical demand), oil about 2 trillion barrels (twice historical demand), and natural gas demand (from natural gas as well as synthetic sources) will be on the order of 25,000 to 30,000 trillion cubic feet (a dozen times more than global cumulative consumption to date).

Non-fossil or so-called renewable energy resources will play an increasing role in energy supply. Their role will likely remain modest in overall supply, at least through the first half of this century.

The challenge of supplying the energy resources for a growing, more affluent world population and reconciling associated economic growth with environmental and other societal needs is huge. The broad geopolitical issues will likewise be challenging. There is, however, plenty in human history, especially the demonstrated human ingenuity to develop the need technology and concepts and to apply them rigorously, to indicate the challenge can be met.

presentation

**december 4, 2006, bureau of economic geology**

# Climate Reconstructions for Europe at the Transition from Neanderthalers to Modern Humans

Eric Barron
*Jackson School of Geosciences*
*The University of Texas at Austin*

A series of experiments using a high-resolution regional climate model embedded in a global climate model have been employed to explore the climate of Europe during Oxygen Isotope Stage 3 (~30,000 to 50,000 years ago). A wealth of data exists for this time period, as synthesized by the Stage 3 Project. The Stage 3 Project was developed in part to consider whether climate was a key factor in the transition from Neanderthalers to modern humans. A key aspect of the model validation is a comparison of model simulated climate and vegetation with the distribution of pollen records, as well as comparisons with a host of other indicators (that is, permafrost evidence). High resolution provides the opportunity to incorporate complex shorelines and topography and to perform careful model-data comparisons. In particular, the high resolution captures considerable complexity in the distribution of predicted vegetation. The

experiments are based on boundary conditions for the Earth's orbit and carbon dioxide 30,000 years ago and a series of sensitivity experiments for ice cap size and for sea surface temperatures. As indicated by the observations, the simulations for 30,000 years ago are substantially cooler than the present day control with much of northern Europe having 15 to 25 °C cooler temperatures in winter and 10 to 15 °C lower in summer. However, there are several areas of mismatch between the observations and the models. These mismatches question whether modern climate-vegetation relationships can be used to simulate past distributions and whether climate models capture the appropriate level of climate variability when applied to climate conditions different from the modern. At the same time, they provide remarkable clues to the environmental conditions that define the distributions of the Neanderthalers.

presentation

**february 5, 2007, bureau of economic geology**

# Early Colonial Trade Patterns in the Southern Plains Elucidated by Lead Isotopes of Musket Balls

Todd Housh
*Jackson School of Geosciences*
*The University of Texas at Austin*

Spain and France disputed control over the southern plains region in the late 17th and early 18th centuries. Although the Red River was agreed upon as a nominal boundary in the early 18th century, historical evidence suggests Europeans were trading with Native Americans across this boundary after that time. Unfortunately, most European goods found in early-colonial (pre-1763) sites in the southern plains are not diagnostic of either Spanish or French origin; thus, it is difficult to ascertain with any certainty who was trading with whom. In this presentation, we will examine lead isotopic data from two well-characterized groups of sites whose histories are relatively well-known during this period: The Wichita villages at Deer Creek and Bryson Paddock in Kay County, northern Oklahoma, and the Spanish mission to the Lipan Apache of San Sabá and the accompanying presidio of San Luis de las Amarillas in Menard County, central Texas. Lead from a variety of sources has been identified: Mississippi Valley-type lead from deposits in the North American mid-continent, as well as lead from Mexican, Central European, and French ore deposits. The inferences we can draw about trading relationships from this lead data are consistent with the historical information for these sites. Thus, we would suggest that lead isotopic characterization of musket balls may also be useful at other sites of this era to infer European-Native American trade patterns.

presentation

**april 2, 2007, bureau of economic geology**

# A Geologic Framework for Western Hays County and Its Application to Groundwater Management

Al Broun

*Hays Trinity Groundwater Conservation District*

With the continued rapid growth and development of Hays County, Texas, and several hot, dry Texas summers, a great deal of pressure has been placed on the groundwater resources of the community. To better understand the geology of the local aquifer systems and as an aid in managing groundwater, a subsurface mapping project was undertaken in 2004 by the Hays-Trinity Groundwater Conservation District.

Cuttings samples and geophysical logs from Hays County water wells were collected and analyzed for lithostratigraphic data and unit tops. The logs were correlated and the resulting stratigraphic interpretation was tied to the outcrop and available literature. A geologic data sheet with information from the interpreted stratigraphy was completed and isopach and structural maps were constructed. Using the interpreted lithofacies, a series of four stratigraphic cross sections were built with average mean sea level as datum. A number of structural cross sections were also constructed. Lithofacies distribution maps and hydrology studies will complete the mapping project.

The Trinity Group in western Hays County is Lower Cretaceous in age, extending from the Neocomian to the Albo-Aptian. Within this Group are three aquifers that supply groundwater to district residents: (1) the Upper Trinity Aquifer (Upper Glen Rose Fm.), (2) the Middle Trinity Aquifer (Lower Glen Rose, Hensell, and Cow Creek formations), and (3) the Lower Trinity Aquifer (Sligo and Hosston formations). The geologic section consists of the wedge-edge of a shallow-water, carbonate shelf which onlapped the thrusted Paleozoic rocks of the buried Ouachita Mountains. The Llano Uplift and highlands to the west and northwest were a provenance for a coarse-clastic sedimentary base (Hosston) that shoals upwards in a series of carbonate-dominated sequences. Tectonic movement during Early Miocene time resulted in a series of northeast-southwest striking, en-echelon, normal faults that cut the Lower Cretaceous sedimentary rocks and dropped the section by as much as 1,200 feet to the south-southeast (Balcones Fault System).

Groundwater in the District is stored in intergranular voids and karstic features of skeletal-grain limestone and vuggy, sucrosic dolomite of the Lower Glen Rose, Cow Creek and Sligo sections. Channel and shoreline sandstones of Hosston age are the reservoir rocks in the Lower Trinity Aquifer. Stacked Rudistid mounds can be mapped in the Lower Glen Rose and often serve as

important, local aquifers. Groundwater moves down gradient through faults, fractures, dissolution features, and the rock matrix of the aquifers. Less permeable, "shaley" intervals in the Upper Glen Rose, Hensel and Hammett formations form local and regional confining layers. The lithology and structural history of the Lower Cretaceous sedimentary section plays an important role in recharge to and yield from these aquifers. A detailed understanding of the subsurface lithofacies distribution and structural history of the Trinity Group rocks may aid in the establishment of district groundwater management areas and an improved stewardship of both the surface and subsurface water sources for the community.

presentation

**may 7, 2007, bureau of economic geology**

# Another Biennium, Another Session: A Groundwater Report from the 2007 Texas Legislature

Robert Mace
*Groundwater Resources Division*
*Texas Water Development Board*

Because water is important to Texas, it's not surprising that water is often a subject of policy discussions and legislation. Therefore, it's not a surprise that water is a target of legislation in the current session, which convened on January 9, 2007. On the groundwater side of water issues, this session has thus far not produced ground-rattling legislation like House Bill 1763 from last session, a bill that redesigned how groundwater availability and groundwater permitting is done in Texas. Nonetheless, there are over 80 groundwater-related bills this session. There are several bills of local interest, including some concerning groundwater conservation districts (expansion of the Plum Creek Conservation District [House Bill 4088], a tweaking of fees for the Barton Springs/Edwards Aquifer Conservation District [House Bill 3572 and Senate Bill 747], and a tweaking of powers for the Hays-Trinity Groundwater Conservation District [House Bill 1591 and Senate Bill 661]) and a bill to submit aquifer test data to the local groundwater conservation district and Texas Water Development Board (House Bill 1313 and Senate Bill 662). Of broader regional interest are bills to address permitting issues in the San Antonio segment of the Edwards (Balcones Fault Zone) Aquifer (house bills 1292 and 3848 and senate bills 659 and 1341) and bills that would affix some special powers to the Hill Country (house bills 3058 and 3447 and Senate Bill 2017). Of broader state-wide interest, there are several bills related to reporting requirements of groundwater use for the exploration of natural gas and to the permitting and reporting requirements for the exploration of uranium for in-situ mining. To date, over 6,000 bills have been filed, many of which will not become law during the 140 day session. Because the session ends May 28, 2007, and the governor's veto pen becomes inactive after June 17, 2007, I am only able to report on the content and status of the bills mentioned above. You may go to http://www.capitol.state.tx.us/ learn about the status of these and other bills for this session.

presentation

**may 7, 2007, bureau of economic geology**

# Recent Experience in Managing Drought-Period Water Use in the Barton Springs Segment of the Edwards Aquifer

W.F. (Kirk) Holland

*Barton Springs/Edwards Aquifer Conservation District*

Droughts are created by both climatological and societal conditions, and drought management must take into account both science and public policy. Groundwater droughts, in particular, are more temporally and spatially variable than other types of drought. The Barton Springs Segment of the Edwards Aquifer serves as a case study to examine the tools used by, and constraints upon, one public agency in dealing with a recent (2005–2007) severe groundwater drought. Extensive historical hydrogeological data played a significant role in evaluating drought trigger usage and in monitoring the recent drought. Methodological and/or policy changes to drought indicators, drought-stage definition, enforcement protocols, public outreach (education), and agency rules were required to respond effectively to this drought. These changes position the agency to be in a better position to respond to future droughts. Less restrictive state statutes and more hydrogeological, hydrochemical, and biological/ecological data and information are needed to enhance this future response.

# posters

## march 5, 2007, bureau of economic geology

The March meeting of the Austin Geological Society was the annual poster session meeting with 18 posters on display. Below is a list of poster titles and authors including four posters by middle and high schools students.

- Geologic Factors Controlling $CO^2$ Storage Capacity and Permanence Techniques and Case Studies Based on Experience with Heterogeneity in Oil and Gas Reservoirs Applied to $CO^2$ Storage—William Ambrose, Srivatsan Lakshminarasimhan, Mark Holtz, V. Nuñez-Lopez, Sue Hovorka, and Ian Duncan; *The University of Texas at Austin.*

- Analyzing Groundwater Flowpaths in a Karstic Basin Using Cross-Plots of Major Ions: Cuarto Ciénegas Basin, Coahuila, Mexico—Megan Andring[1], Brad Wolaver[2], John Sharp[2], and Jay Banner[2]; [1]*Slippery Rock University and* [2]*The University of Texas at Austin.*

- The Geochemistry of Beryl and its Implications for the Classification of Granitic Pegmatites—Ana Collins[1] and Michael Wise[2]; [1]*The University of Texas at Austin and* [2]*Smithsonian Institute.*

- Geologic Map of the Glenn Spring Quadrangle, Big Bend National Park, Texas—Edward W. Collins[1], William R. Muehlberger[1], and Patricia Wood Dickerson[2]; [1]*The University of Texas at Austin and* [2]*Lockheed Martin.*

- Recent Travertine Deposits as Records of Groundwater Processes in Urbanizing Environments—Lauri DeMott, Jay Banner, and Lance Christian; *The University of Texas at Austin.*

- Discriminating Orogenic Elements at Lower Crustal Levels in Andinotype Structures vs. Intraplate Results of Gondwana Collisions—Patricia Wood Dickerson; *Lockheed Martin.*

- Source-to-Sink Sand and Mud Partitioning across a 400 km Regressive-Transgressive Clastic Wedge of 3rd Order in the Western Interior Seaway (Campanian)—Caroline Gomez, and Ron Steel; *The University of Texas at Austin.*

- Potentiometric Maps of the Barton Springs Segment of the Edwards Aquifer, Travis and Hays Counties, Texas—Brian Hunt and Brian Smith; *Barton Springs/Edwards Aquifer Conservation District.*

- ENSO and PDO Impacts on Precipitation in Southern and Central US: Evaluation of Spatial Distribution and Predictions—Daniel Kurtzman and Bridget Scanlon; *The University of Texas at Austin.*

- Bed Material Transport Measurements within the Lower Mississippi River—Jeffrey A. Nittrouer[1], David Mohrig[1], and Mead Allison[2]; [1]*The University of Texas at Austin and* [2]*Tulane University.*

- Groundwater Development in Aquifers with Naturally Occurring Arsenic—Bryan Mitchell[1], Candy Staring[2], Matt Mantell[2], and Ken Nichols[2]; [1]*City of Norman, Oklahoma, and* [2]*CH2M Hill.*

- Changing Recharge and Hydrogeology in an Urbanizing Area: Example of Austin, Texas, USA—John M. Sharp, Lance N. Christian, Beatrix Garcia-Fresca, Suzanne A. Pierce, and Thomas Wiles; *The University of Texas at Austin.*

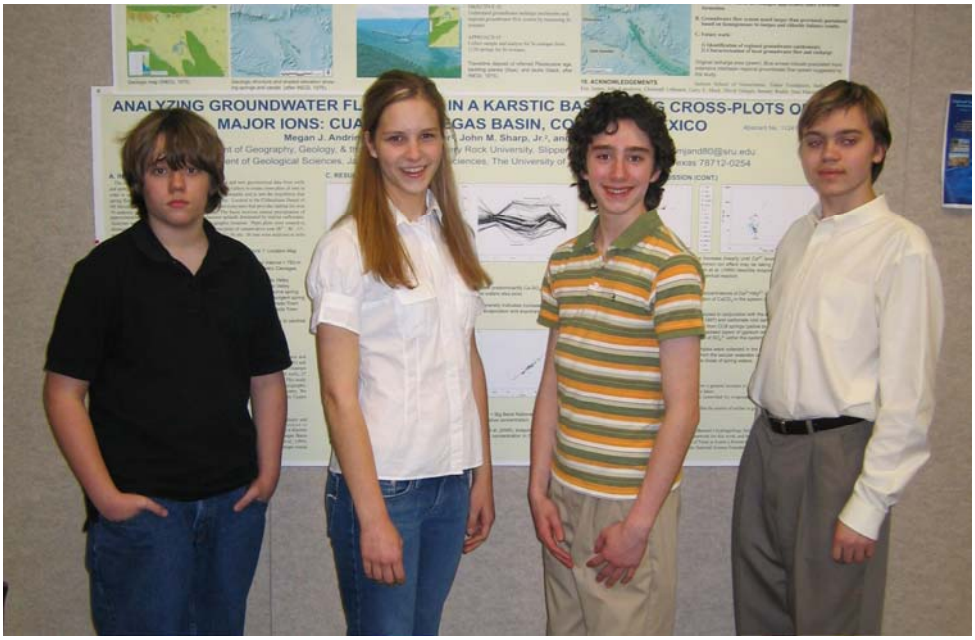
- Early Primates: When and Where? And How Did They Appear in West Texas?—Girish Tembe and Timothy Rowe; *The University of Texas at Austin.*

- Integration of Core, Image and Wireline Logs in the Olmos Formation—Ramon Trevino, Robert Loucks, Julia Gale, and Adbelmonieum Adbelmonieum; *The University of Texas at Austin.*

- Groundwater Recharge in the Cuarto Ciénegas Basin, Mexico: Insights from Strontium Isotopes and Trace Element Analysis—Brad Wolaver, John Sharp, and Jay Banner; *The University of Texas at Austin.*

# Student science fair posters

The Austin Geological Society participated in the exhibit judging at the Austin Regional Science Festival in February 2007, specifically of the Middle and High School Earth Science and Environmental categories. Seven students were given Certificates of Recognition for their projects and were invited to present their exhibits at the annual poster session meeting in March. They were also invited to submit abstracts of their projects for publication in the Bulletin. The students submitted the following abstracts for publication.




*Thomas Morris, Jenna Kromann, Andy Garcia, Trey Henniger* *Photo by Bob Bluntzer*

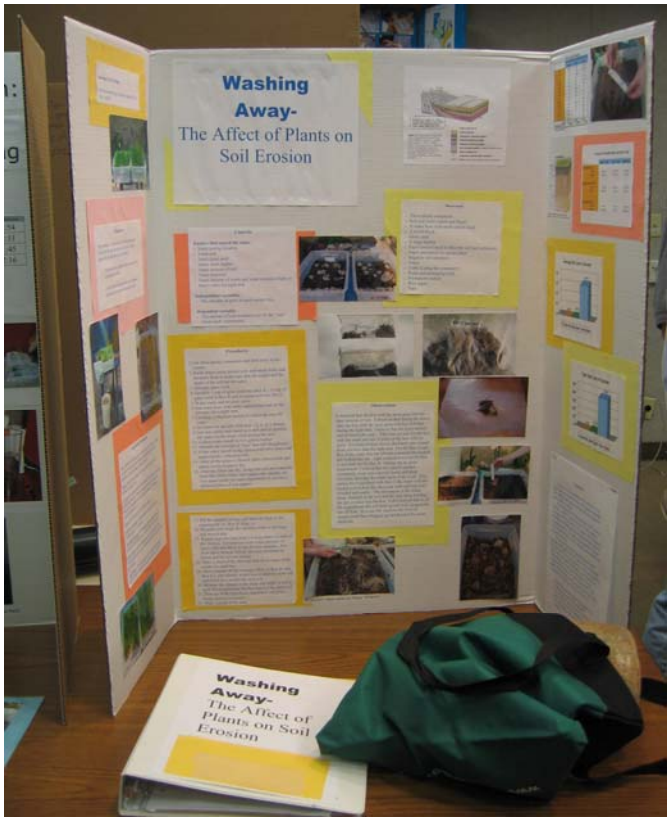



*Photo by Bob Bluntzer*

# Washing Away—The Effect of Plants on Soil Erosion

Andy Garcia
*Murchison Middle School*

Soil erosion impacts both crop productivity and ecosystems of fish and wildlife. The purpose of this experiment was to determine if the amount of vegetation affects soil erosion. To determine if the hypothesis that grass reduces the amount of soil eroded was true the, following procedures were used. First, different amounts of grass were planted in three plastic boxes—the first box with a lot of grass, the second with a little grass, and the third with no grass. After the grass had grown, light and heavy rainfall was simulated using a water hose with a multi-option head. During each trial the time and strength of the rain was kept the same for each of the boxes. The water runoff was collected and the water filtered to remove the dirt. The dirt from each trial was measured and the results from the three boxes were compared.

The data from the trials showed that the box with the most grass lost the least amount of soil and the box with no grass lost the most. The average soil lost per trial was: 0.075 ounces for the box

with grass, 0.775 ounces for the box with little grass, and 31.97 ounces for the box with no grass. Total soil loss was 1.125 ounces for grass, 11.625 ounces for little grass, and 222.8 ounces for no grass.

The conclusion is that grass helps to prevent soil erosion. The hypothesis of the experiment was correct.

*Andy Garcia is a 7th grader at Murchison Middle School, Austin Independent School District.*

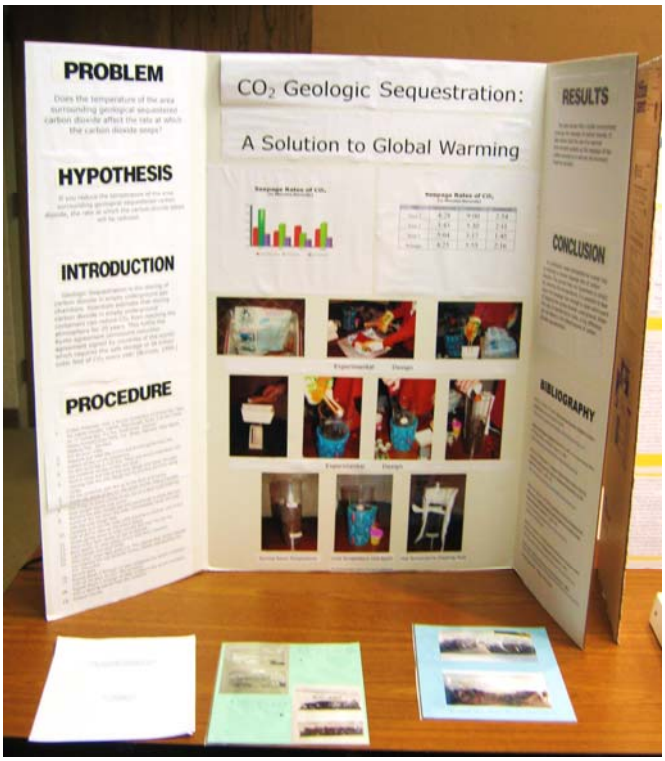



*Photo by Bob Bluntzer*

# $CO^2$ Geologic Sequestration: A Solution to Global Warming

Trey Henniger
*Bowie High School*

This project evaluated the effects of temperature on the migration of carbon dioxide in a subsurface environment. The test procedure was to detect the presence of carbon dioxide, at concentrations higher than normal atmospheric, through its ability to extinguish a flame. This was determined with a candle flame, located just above the containerized soil in which the carbon dioxide was stored.

The carbon dioxide was first inserted into the soil as dry ice. The carbon dioxide would then have to seep its way through six inches of soil to the candle at the top of the container, which gave a measurable variable—time. When the candle went out, it was known that the carbon dioxide had reached the top of the container, having seeped through all six inches of soil.

Several tests were run to fine-tune the test procedures. Then, three trials were made for each test group. In normal temperature soil, carbon dioxide seeped through the six inches of soil in an average of four minutes, twenty-five seconds. In heated soil (accomplished with a heating pad), the average seepage time was two minutes, sixteen seconds. In colder soil (accomplished with an ice pack), the average seepage time was five minutes fifty-five seconds.

The data proves that colder temperatures lower the seepage rate. This concept indicates that countering global warming may reduce natural carbon dioxide emissions into the atmosphere.

*Trey Henninger is a 9th grader at Bowie High School, Austin Independent School District.*

# The Effect of Drought on the Salinity Zone in the Edwards Aquifer

Jenna Kromann
*Bowie High School*

This investigation was conducted to determine if drought affects the freshwater-saline water interface ("bad water line") by degrading the water quality in the Edwards Aquifer. Water samples were collected from several wells located within the interface zone of the Barton Springs Segment of the Edwards Aquifer. The pH, conductivity, and temperature of the samples were measured at the time of collection, and the depth to water was measured in each well. The water samples were subsequently tested for alkalinity, chloride, hardness, nitrate, sulfate, and sulfide using a spectrophotometer and digital titrator.

The results of these analyses were then combined with historical water quality data (Texas Water Development Board and Barton Springs-Edwards Aquifer Conservation District databases) from the same wells and other wells in the study area (for a total of 19 wells). The water quality data was grouped into drought and non-drought periods, based primarily on the flow rate of Barton Springs (principal discharge point for this segment of the Edwards Aquifer). Extended periods of low or high flow were used to define drought or non-drought periods, respectively. Isopleth maps of chloride, sulfate, and total dissolved solids concentrations were then constructed for each high and low flow period to illustrate spatial water quality changes as a function of drought and non-drought conditions.

The results of the experiment indicate that during drought (low-flow) conditions there was a shift, towards the west, in the interface between the saline zone (to the east) and freshwater zone (to the west). This shift was indicated by increases in the total dissolved solids, chloride, and

sulfate concentrations in wells on the west side of the interface. Conversely, during non-drought (high-flow) periods, these concentrations decreased, due to the greater rate of freshwater recharge into the aquifer, and the interface shifted towards the saline zone (east). The data supports the hypothesis that during drought conditions, the freshwater-saline water interface will shift towards the freshwater zone, causing some water quality deterioration in that zone.

*Jenna Kromann is an 11th grader at Bowie High School, Austin Independent School District.*

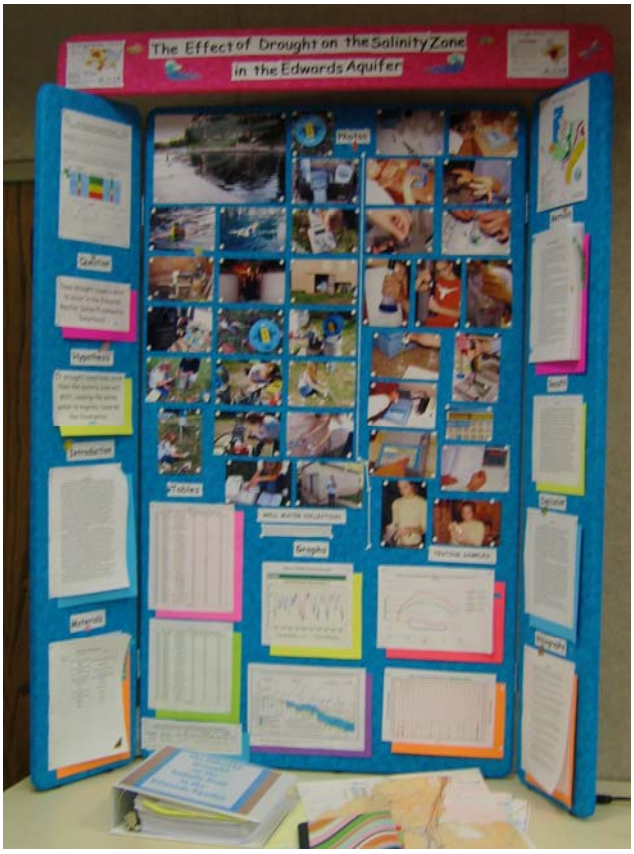



*Photo by Bob Bluntzer*

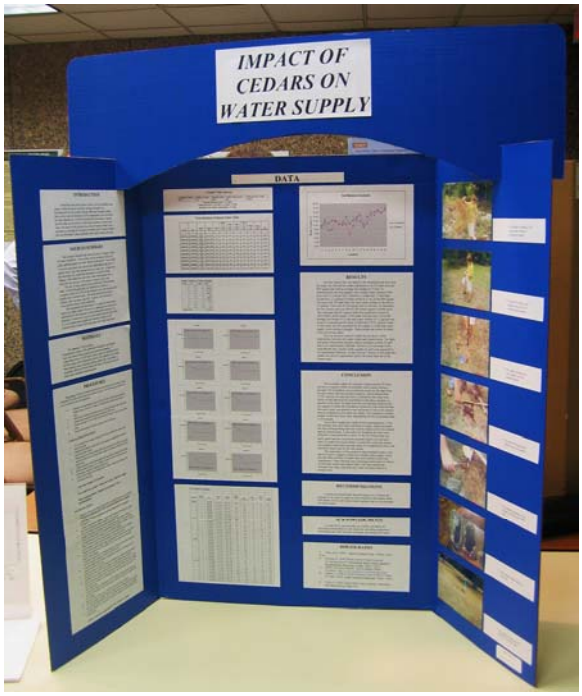



*Photo by Bob Bluntzer*

# Impact of Cedars on Water Supply

Thomas Morris
*Lamar Middle School*

Certain species of cedar (juniper) trees have been shown to take a toll on available water supply, which can be a serious problem, particularly during a drought. The purpose of this experiment was to determine if mountain cedars in the Lake Travis area hold and consume large amounts of water. Procedures in this experiment include: a census of mountain cedars taken in a 900 square foot area; a sampling of 10 live, mature cedar trees to determine water content through wood sample drying and weight loss measurements; and soil moisture analyses of 38 core samples (6 to 10 inch depth) to compare moisture levels under cedar trees to open (control) areas. The data confirmed that the cedars in the natural growth area retained a large amount of water, specifically 2,760 gallons per acre. The results also indicated that the average cedar retains 0.1 gallons of water per foot of tree height. The soil core analyses did not show the expected results of less moisture in soil under the cedars as compared to soil in the cleared area. However, the author noted that the surface soil under the cedars appeared drier than soil at the surface in cleared areas after a rain. For this reason, suggested future research would include soil analyses of samples collected at the surface rather than core samples. Based on these results, it was concluded that cedars do retain large amounts of water and that the water that they consume would be available for other uses (other vegetation, aquifer recharge, etc.), if the cedars were not so prevalent.

*Thomas Taylor Morris is a 7th Grader at Lamar Middle School, Austin Independent School District.*

field trip

# Spring 2007 Field Trip

# Geology of the Karnes Uranium District, Texas


***trip coordinators:***

Alan J. Cherepon, Jon E. Brandt, and William E. Galloway

***contributors:***

Alan J. Cherepon, Jon E. Brandt, and William E. Galloway

***trip summary and photos:***

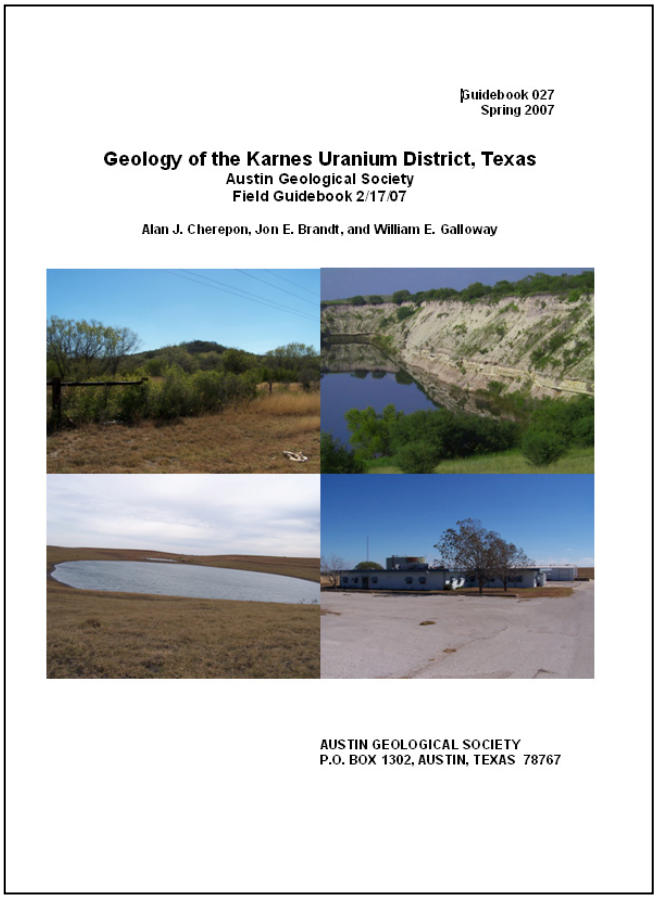
Alan J. Cherepon


The annual field trip took place on February 17, 2007, titled "Geology of the Karnes Uranium District, Texas". This was Guidebook 27, which included the same innovations from the trip last year (digital photos, a compact disk of additional photos and materials, GPS locations, and such). The co-authors and co-leaders included Alan J. Cherepon, Jon E. Brandt, and William E. Galloway. The combined experience of these three is more than 30 years, primarily in Texas. Numerous diagrams, maps, and photos were done or provided through the Railroad Commission of Texas, especially those provided by Jon Brandt. Other contributors included Paul Bordovsky and Ron Parker who provided some photographs and additional input for the trip. Several of the finished diagrams in the guidebook were authorized for guidebook use by The University of Texas, Bureau of Economic Geology. All stops required access, including Mr W.T. Brazil and Ms. Arnold Kolpack for access to Tordilla Hill, Mr. Hermann (Junior) Kellner for the Kellner Mine at Stop 3, and Mr. Jeff Beiker for access to the Sickenius Mine at Stop 4.

The trip objective was to revisit an area where numerous field trips have been held and to address several aspects of the region not addressed in earlier trips. Instead of just addressing the uranium geology of earlier trips, a diversity of subjects was covered. These included a general history and detailed geology of the district, reclamation and environmental aspects of these pre-mining law open pit mines, and the diverse mineralogy associated with the mines.

The trip was a result of the anticipated reclamation of the last remaining open pit mine in the main uranium trend. The Sickenius Mine, scheduled for reclamation in 2007 and the last pit with great stratigraphic exposures and mineralized concretions, lead the authors to believe this would be one of the last opportunities to observe, study and, in a way, preserve some of the details of the area's geology for the next generation, who were too young to have been professionally

active when these deposits were being mined. The trip also came at a time when uranium prices have jumped to about six times what they were a year prior to the trip. These sharp increases in uranium prices have caused a renewed interest in uranium exploration and production in South Texas, making this a timely revisit of Texas Uranium. For several of us who were previously employed by the uranium industry, it was also a nostalgic trip down memory lane.


Guidebook 027
Spring 2007

**Geology of the Karnes Uranium District, Texas**
Austin Geological Society
Field Guidebook 2/17/07

Alan J. Cherepon, Jon E. Brandt, and William E. Galloway

AUSTIN GEOLOGICAL SOCIETY
P.O. BOX 1302, AUSTIN, TEXAS 78767

Some 72 people attended the trip, filling the chartered bus, most of a 13-passenger van, and about three private vehicles. Attendees included not only Society members but several Austin Gem & Mineral Society members and a small number of South Texas Geological Society members. A total of 4 stops were planned, plus a potential fifth stop if time allowed. Highlights of the trip included a visit to Tordilla Hill, the initial discovery and mining site for Texas Uranium, and collecting minerals at the Sickenius Mine. Other stops included brief visits to the first two uranium mill sites in the state, viewing a reclaimed pit, and viewing some of the sedimentary structures in a pit off the main trend. One adjustment had to be made at the Kellner property. Due to an unforeseen conflict where the owner could not be present, the reclaimed Pfeil and Wright-McCrady pits were visited instead of the Kellner pit. Unfortunately, the group could not collect at the concretion mounds at these pits. Also, a stop to a local restaurant for some killer steaks had to be cancelled at the last minute due to the owner overbooking (at least we all returned home at a reasonable hour). Overviews were provided by the co-leaders/authors at each stop, as well as question and answer discussions. Paul Bordovsky, one of the locals and presently a dentist and resident of Austin, provided the group with an overview and details of what it was like working at the uranium mills when they were in operation.

The weather was great, with the rains and sleet that occurred earlier in the year holding off during the day of the trip. While it was a long trip (taking about two-plus hours to drive each way), few seemed to mind as the time was filled with further discussion of what was seen or to be seen. All who attended expressed their enjoyment for this opportunity to visit and review Texas uranium geology and the environmental issues associated with the district.

**Field trip participants at Stop 2, the Boso Pit at the base of Tordilla Hill, the first uranium mined in Texas**

**Bill Galloway, Al Cherepon, and Jon Brandt commenting on the Boso Pit at Tordilla Hill.**

note

# Edwards Aquifer Monitoring Well at Austin Community College

Robert H. Blodgett, Cindy A. Carr, and John S. Conners
*Austin Community College*

Austin Community College has teamed up with seven partners in the private sector and in government to establish a monitoring well in the Edwards aquifer. This well is located in a new 200-square foot educational building at Austin Community College's Northridge Campus and will be linked to a Web site in the coming year.

The well, State Well Number 58-35-811, was donated to the College by Alcoa's Sandow Mine and by Tyler-based MHC X-Ploration Corporation. Located northwest of Braker Lane and Metric Boulevard in Austin, the 610-foot-deep well is in the transition zone of the Edwards Aquifer. The college now has over two years of measurements taken from the well.

In addition to its monitoring function, the college was able to film construction of the well with a grant from the Texas Mining and Reclamation Association. During well construction, drillers from MHC X-Ploration took core from the Atco, Eagle Ford, Buda, and Edwards formations. Preparation of this core was donated to the college by the Bureau of Economic Geology and half of the core is archived in the bureau's Core Library. Austin Community College students describe and interpret the core in a historical geology class project. In addition to the core, the college also has a geophysical log and downhole video for the well that were donated by San Antonio-based GeoCam, Inc. A video clip of the porosity in the Edwards Aquifer will appear on the college's Web site.

What makes the Austin Community College monitoring well especially valuable is that it collects both water level and water quality information. Water level and water temperature data are collected with an In Situ MiniTroll probe permanently installed in the well. Hydrolab, a division of the Hach Company, donated a Datasonde 4a water quality probe to the college. This probe is used to make weekly analyses of pH, specific conductance, and dissolved oxygen.

The college has recently added a Texas Weather Instruments weather station to the wellhouse. This station records precipitation, air temperature, barometric pressure, humidity, wind speed, and wind direction data which will be included on the college's Web page.

Faculty and staff of the Austin Community College Geology Program would like to thank the business and government partners who donated time and services for the construction and installation of the well and express appreciation to hydrogeologists Ted Harriger, Nico Hauwert, David Johns, and John Mikels for advising the college on the well project.

*Ripple marked building stone in Hye, Texas. Photo by Brian Hunt.*

note

# Geologic Mapping for the Texas STATEMAP Program

Edward W. Collins
*Bureau of Economic Geology*
*Jackson School of Geosciences*
*The University of Texas at Austin*

The STATEMAP program, part of the National Cooperative Geologic Mapping Program, which began in the early 1990s, has benefited Texas by increasing the State's coverage of detailed geologic maps. In general, geologic mapping for the Texas program has been conducted in areas where high-quality geologic maps provide important data that support responsible decision-making regarding the utilization of land and natural resources. An important element of the program is that awarded federal funds require matching state funds. A long-range goal of the program is to provide a digital geologic map database that is sufficiently detailed (1:24,000 to 1:100,000) to serve as a data source for most basic and applied earth-science investigations for Texas. Maps constructed under the Texas STATEMAP program are intended to complement existing geologic maps of various sources. Two statewide map series include the 1:250,000-scale Geologic Atlas of Texas sheets (Barnes, program coordinator, 1965–1994) and the 1:500,000-scale Land Resources of Texas sheets (Kier and others, 1977).

Texas has multiple needs for geologic maps because of the state's large and variable geographic extent. Throughout Texas, population increases, geographic shifts in population density, drought, and natural- and human-influenced changes in sensitive environments such as the Texas coast have created demands on land and water resources. Geologic maps provide data necessary for making responsible decisions regarding land use and management of water and other natural resources. To help evaluate and prioritize possible study areas, three categories of equal importance have been established:

(1) areas having specific environmental and natural resource concerns,

(2) urban and rural corridors experiencing population growth and demands on earth and water resources, and

(3) critical aquifers and their recharge areas.

Map study areas have included the Texas coast, central and west Texas areas that are undergoing rapid urban development, areas of major and minor aquifers throughout the state, and state parks (Figure 1). Geologic maps for these areas are typically important elements of multicomponent data sets that are needed to support responsible decision-making regarding utilization of land and water resources. For example, along the Texas Gulf Coast, maps address geologic framework needs for planning and managing land use, evaluating historical changes of coastal depositional

environments, addressing erosion issues, permitting activities related to resource development, and educating the public. In Central Texas, such as the corridors north, east, and west of Austin, maps provide basic geologic framework data to aid in managing water and earth resources, planning land use, identifying aquifer recharge areas, identifying sources of aggregate and other earth resources, designing construction projects, and recognizing areas having stratigraphic units and associated soils prone to foundation problems. The maps can be used as base maps for site-specific studies, such as the detailed mapping and description of geologic features that affect aquifer recharge.

Geologic maps are made available to the public at a scale of 1:24,000 and 1:100,000. Some maps are currently available in a digital, Geographic Information System (GIS) format. A program goal is eventually to provide all new Texas maps in a GIS format to fulfill the needs of users.

# References

Barnes, V.E., program coordinator, 1965–1994, Geologic atlas of Texas: The University of Texas at Austin, Bureau of Economic Geology, scale 1:250,000, 39 sheets.

Kier, R.S., Garner, L.E., and Brown, Jr., L.F., 1977, Land resources of Texas: The University of Texas at Austin, Bureau of Economic Geology, scale 1:500,000, 4 sheets.

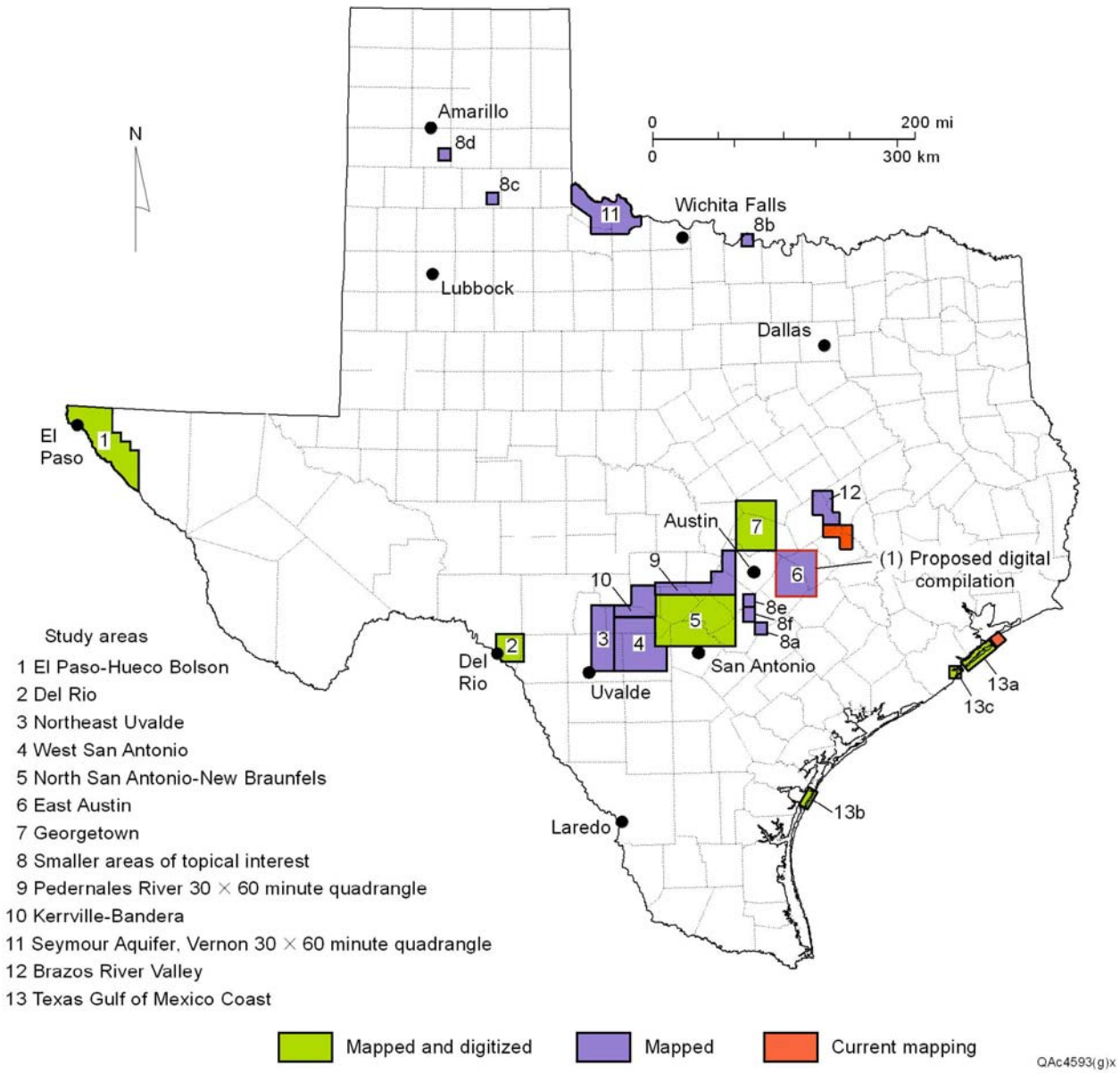



**Figure 1. Texas STATEMAP Program study areas.**

note

# Legislation related to Groundwater Resources from the 80th Texas Legislature

Robert E. Mace
*Texas Water Development Board*

The 80th Legislative Session came to a frenetic close at the end of May with a number of important water-related bills passing in the waning moments before sine die. The bills with the biggest post-session buzz were Senate Bill 3 and House Bill 3, bills that created a process for establishing environmental flows standards for the state's rivers, among other items. Recognizing the importance of groundwater for environmental flows, the legislature included a seat for groundwater conservation districts on each basin and bay area stakeholders committee for each river basin and bay system in the state. Senate Bill 3 also created the Water Conservation Advisory Council to provide the governor, lieutenant governor, speaker of the house, legislature, board, commission, political subdivisions, and public with expertise in water conservation. Groundwater conservation districts have a seat on this council.

Another big part of Senate Bill 3 concerned the Edwards Aquifer Authority. The bill raised the permitted pumping cap from 400,000 acre-feet per year to 572,000 acre-feet; revised the critical period withdrawal reduction stages; and created a process to develop a critical period management plan to protect endangered species at Comal and San Marcos springs.

Other items in Senate Bill 3 include:

- policy statements in support of voluntary land stewardship as a water management tool to help increase surface water and groundwater supplies;
- an expedited process for amending regional water plans;
- a special provision for groundwater conservation districts in the priority groundwater management area in the Hill Country to consider the provision of water to a pond, lake, or reservoir to enhance the appearance of the landscape when granting permits;
- allowing the creation of the Sustainable Water Supply Research Center at The University of Texas at Arlington;
- the designation of unique reservoir sites and sites of unique ecological value according to recommendations in the regional and state water plans; and
- creation of the Tablerock Groundwater Conservation District in Coryell County.

The legislature did not change the joint planning process in groundwater management areas established in House Bill 1763 in the 79th session. However, they did add a policy statement to Chapter 36 of the Water Code that states: "It is the policy of the state to encourage public participation in the groundwater management process in areas within a groundwater management area not represented by a groundwater conservation district." Also, be sure to see the news item in this issue related to how new districts participate in the groundwater management area process.

The legislature created seven groundwater conservation districts, including

- Colorado County Groundwater Conservation District (House Bill 4032),
- Lavaca County Groundwater Conservation District (House Bill 4029),
- McLennan County Groundwater Conservation District (Senate Bill 1985),
- Northern Trinity Groundwater Conservation District (Tarrant County; House Bill 4028),
- Panola County Groundwater Conservation District (House Bill 1498),
- Tablerock Groundwater Conservation District (Coryell County; Senate Bill 3), and
- Upper Trinity Groundwater Conservation District (Hood, Montague, Parker, and Wise counties; Senate Bill 1983).

All but the Northern Trinity Groundwater Conservation District will have to hold elections to confirm the creation of the districts. The Culberson County Groundwater Conservation District received authorization to add the rest of Culberson County to the district's territory provided voters approve (Senate Bill 3).

There were also changes to the enabling legislation for the following districts:

- Barton Springs-Edwards Aquifer Conservation District (Senate Bill 747),
- Bee County Groundwater Conservation District (Senate Bill 404),
- Brazoria County Groundwater Conservation District (House Bill 4114),
- Duval County Groundwater Conservation District (House Bill 2070),
- Emerald Underground Water Conservation District (House Bill 4009),
- San Patricio County Groundwater Conservation District (Senate Bill 2029),
- Emerald Underground Water Conservation District (now Crockett County Groundwater Conservation District; House Bill 4009),
- Starr County Groundwater Conservation District (House Bill 2072), and
- Tri-County Groundwater Conservation District (now Gateway Groundwater Conservation District; Senate Bill 1950).

Other bills of interest to groundwater resources:

- House Bill 2654 allows general permits (and easier permitting path) to be used to permit wells for deep well disposal of brine concentrate from desalination plants;
- House Bill 3837 and House Bill 3838 address the regulation of injection and exploration wells for in situ uranium mining;
- Senate Bill 662 requires developers to send copies of pumping test information to the Texas Water Development Board and the local groundwater conservation district if they are required by a county or city to certify they have enough groundwater for the development;
- Senate Bill 714 allows groundwater conservation district to require water use reporting for all water wells (including those used to support oil and gas operations) except those used for household and livestock use;
- Senate Bill 1383 relates to district hearings and citizen suits for illegally drilling or operating a water well;
- Senate Bill 1604 concerns the disposal of low-level radioactive waste; and
- Senate Bill 1037 relates to the prevention of surface water or groundwater pollution from certain evaporation pits.

To see these bills, go to http://www.capitol.state.tx.us/ and type in the bill name, click on the text tab, and be sure to look at the enrolled version.

note

# Stratigraphic Distribution of Cave Volume in the Edwards Limestone, Southern Travis County, Texas

William H. Russell
*Texas Speleological Survey*

## Introduction

The Edwards Aquifer of Texas, especially the Barton Springs Segment of the aquifer just south of Austin, is developed in limestone units with several distinctive hydrologic members (Hanson, 1995; Hanson and Small, 1995; Small and others, 1996). These members provide a unique opportunity to examine the effects of variations in stratigraphy on the development of caves and solution conduits.

Many current accounts of speleogenesis discuss in detail the development of large cave systems, but one important aspect is generally neglected: the stratigraphic control of solution. Most discussions assume the existence of a thick, relatively homogeneous sequence of soluble rock. They discuss in detail the influence of joints, bedding planes, regional groundwater levels, and upwelling aggressive groundwater and the production of sulfuric acid and mention the occasional "resistant horizon" like the Hartstelle Sandstone in the southeastern United States. But there are few discussions of cases like the Edwards Aquifer of Texas, where groundwater flows along the strike of the limestone for long distances, units of varying physical and chemical composition are exposed to solution, and groundwater is free to establish flow paths through favorable units. In the Edwards Aquifer, there is a complex interplay between chemical composition, mechanical strength, grain size, chemical composition, and digenetic history. The study of the stratigraphic control of solution in the Edwards Aquifer provide important information on the role of stratigraphy in karst development and have important implications for reservoir formation and water resource development.

## Methods

The location (TSS, 2007) and stratigraphic position of the solution volume of 122 caves in the outcrop area of the Barton Springs Segment of Edwards Aquifer was determined: all caves in the Travis County portion of the aquifer were surveyed, except for 14 small caves on the cliffs overlooking Town Lake and 15 small caves for which the stratigraphic position could not be determined due to uncertainty in location. In addition, one cave on the Travis-Hays county line and one cave a few hundred feet into Hays County are included. Many of the caves intersected an obvious marker bed, which was used to determine the stratigraphic location of the solution

volume. In caves without marker beds, the position of the cave was plotted on a geologic map of the Barton Springs Segment of the Edwards Aquifer (BSEACD, 1997, and more recent editions), and the stratigraphic location was determined. Then, using cave maps from the Texas Speleological Survey, the volume of the cave was divided into 10-foot stratigraphic intervals. There was no attempt to adjust the solution volume to include the volume of sediment in a cave; only the actual observable space was counted. Overall, cave fills, mostly Pleistocene red clay and recent black clay from surface erosion, have reduced the cave volume by only a small percentage. In addition, shelter caves were not included in the study since much of their volume is due to enlargement by surface-related processes.

A standard stratigraphic column for the Edwards Aquifer was developed as a model against which to plot the stratigraphic position of each cave volume. The members were assumed to have the following thicknesses (based on information from Brune, 1983; Hanson, 1995; and Hauwert, 1995): Leached-Collapsed: 70 feet, Regional Dense: 20 feet, Grainstone: 50 feet, Kirschberg: 70 feet, Dolomitic: 130 feet, and Walnut: 60 feet, for a total Edwards Aquifer thickness of 400 feet. This is only an approximation as the members do not have a constant thickness across the area surveyed. If the average thickness of a member is somewhat exaggerated, then the relative cave volume shown for this member will be diminished, but this effect is not believed to be large except for the Leached-Collapsed Member. To preserve the relationship between the Regional Dense Member and stratigraphic position, all stratigraphic thicknesses are measured from the base of the Leached-Collapsed Member just above the Regional Dense Member, and since the Leached-Collapsed Member thins across the study area, the upper portion of the member is likely somewhat more favorable for cave development than indicated.

# Results

The total volume of accessible cave in each ten-foot stratigraphic interval was plotted to form the graph displayed in Figure 1. As might be expected in a sequence of rock with different depositional environments and chemical composition, the amount of solution volume in each interval varies considerably, ranging from a complete absence of known caves to zones with numerous significant caves.

The total cave volume measured was 724,980 cubic feet in an outcrop area of about 44 square miles, or 1,226,649,600 square feet. This is approximately 0.0006 cubic feet of cave volume per square foot over the entire Edwards outcrop. If the Edwards Limestone in the outcrop area averages 300 feet thick (400 feet stratigraphic thickness less 100 feet of erosion) and the average percentage of interconnected voids is 5 percent, then there is 300 times 0.05 or 15 cubic feet of volume under each square foot. So far, we have access to 0.0006 cubic feet of cave per square foot of outcrop, or 0.004 percent (0.0006/15) of the potential volume. Even though much of this volume is in openings too small for humans to enter, there is likely much more cave to be found.

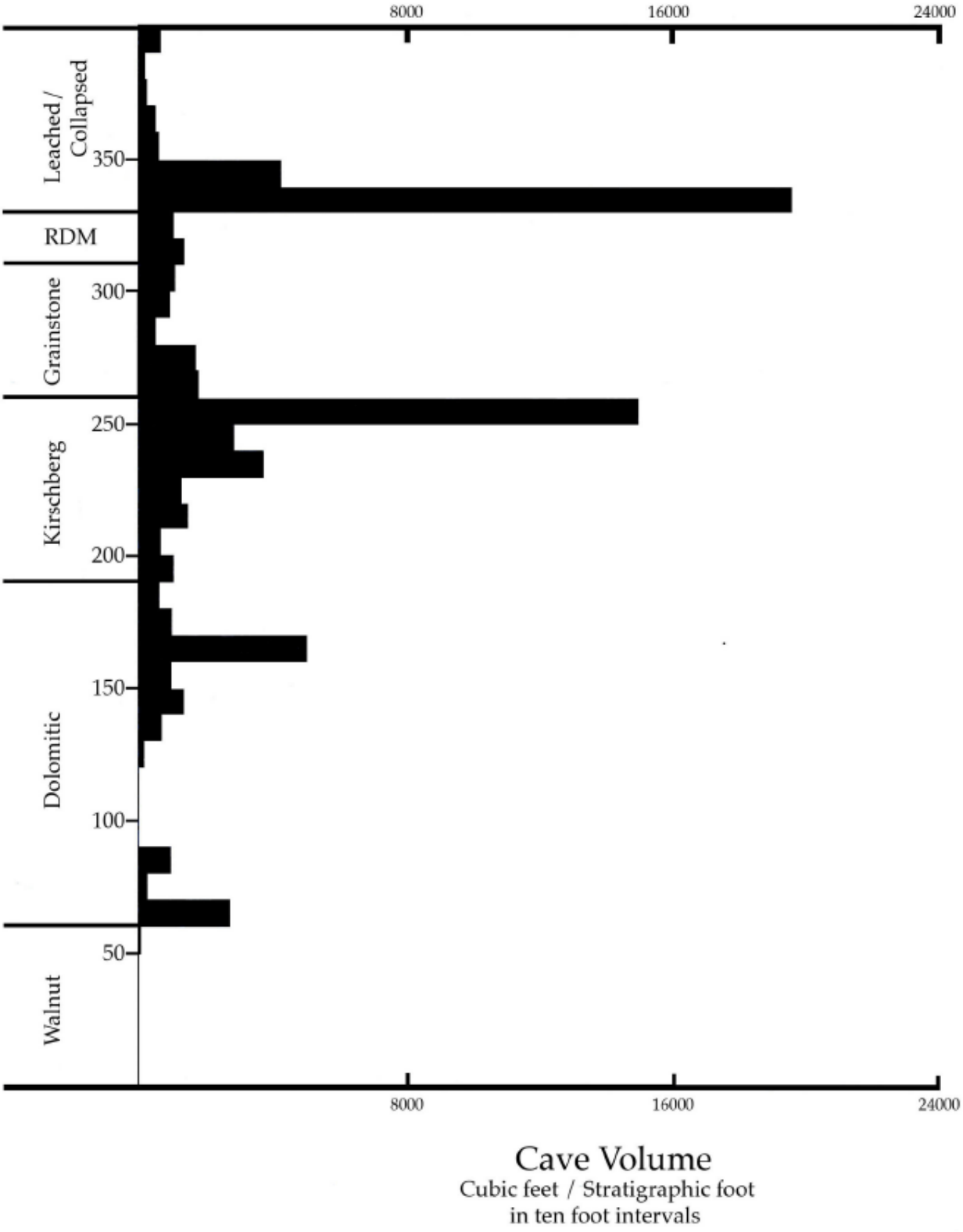



**Figure 1. Distribution of Cave Volume in the Edwards Limestone in Southern Travis County, Texas. The vertical axis is the stratigraphic thickness measured in feet.**

# Discussion

There are two conspicuous zones in the Edwards Aquifer especially favorable for cave formation. The uppermost is the Upper Solution Collapse Zone, first identified by Rodda (Rodda and others, 1970) that includes Airman's Cave and numerous smaller caves. This zone is developed at the base of the Leached-Collapsed Member, just above the Regional Dense Member. The Regional Dense Member is resistant to solution and acts as a local barrier to water flow, forcing groundwater to flow laterally through solutionally favorable beds in the lowermost Leached-Collapsed Member, greatly increasing the amount of solution at this level and causing the collapse that gave this member its name.

The other zone especially favorable for cave formation is the uppermost Kirschberg Member, where many caves are formed along the contact between the Kirschberg Member and the overlaying Grainstone Member. The Kirschberg Member is a very soluble unit but is mechanically weak. Caves developed at the top of this member are protected from collapse by competent beds of the overlying Grainstone Member, while conduits developed within the member are blocked by frequent collapse, limiting their ability to form large cave systems. Caves developed at the top of the Kirschberg Member include Whirlpool Cave, County Line Bat Cave, Barker Bat Cave, Tres Amigos Cave, Get Down Cave and many others. Less prominent concentrations of cave development also occur near the top of the Dolomitic Member and near the base of the Dolomitic Member.

There is a 30-foot zone in the lower Dolomitic Member with no known cave development. Streams in the lower levels of Blowing Sink Cave are perched on this insoluble zone, passages in Flint Ridge Cave end at this stratigraphic level, and Backdoor Spring that flows into Barton Creek is developed above this zone. This zone is not completely effective in blocking water flow—fracturing along faults likely allows some flow though this unit—but it does tend to concentrate solution above this zone. There is very little cave development in the Walnut Member, on which a few springs are perched but, in most areas, there is enough solution in the Walnut Member so that springs issue from within the member.

As in most karst areas, Travis County caves have a logarithmic size distribution with a few large caves and a large number of small caves. The largest cave, Airman's Cave, has a volume of 138,000 cubic feet or 19 percent of the total explored volume. This cave represents 71 percent of the volume of the upper solution/collapse zone; if the entrance to this cave had not been dug out by cavers, the upper solution/collapse zone would appear to be less prominent. Though the distribution of cave volume is strongly influenced by the few large caves, cavers looking for caves were not aware of the geologically favorable parts of the Edwards Aquifer outcrop, so all areas were searched with equal diligence. Thus, the distribution of explored cave volume likely approximates the distribution of all large voids in the Edwards Aquifer. Outcrop characteristics and water well data also support the conclusions derived from the cave data. The observed distribution of large voids does not appear to be just an artifact of exploration.

The distribution of sinkhole volume is significantly different from the distribution of cave volume. Large surface sinks are concentrated on the outcrop of the Kirschberg Member, where over 90 percent of the sinkhole volume is also located, while only 33 percent of the cave volume is in the Kirschberg Member. This is due to the nature of the Kirschberg Member, with numerous thin, easily dissolved beds that are entirely removed by solution, causing collapse that forms

laterally extensive debris piles. The openings in this solution rubble transmit large amounts of water but are much too small to be explored, and so do not count as cave volume. The major cave-forming conduits develop at the top of the Kirschberg Member, where the overlying Grainstone Member forms a supporting roof that allows large openings to form. When the solution rubble is exposed to surface weathering, it tends to form broad shallow sinkholes, as weathered surface material is carried down into the numerous voids.

At least 20 percent of the solution volume listed for the Regional Dense Member is not solution, but rather volume created by collapse. The Regional Dense Member normally acts as a barrier to groundwater flow, and so caves form where groundwater can flow though fractures in the Regional Dense Member. These fractured areas concentrate flow into the underlying more soluble units and form large solution voids. Thereafter, large blocks of the fractured Regional Dense Member collapse into the voids. In most cases, an accurate estimate of the volume of the collapsed blocks was not possible, so no attempt was made to adjust the volume to exclude the collapse volume.

# Acknowledgments

This report would not have been possible without the help of the many cavers who have contributed information to the Texas Speleological Survey. Their many hours spent mapping and exploring the caves of the area have provided the information used in this note. The cooperation and comments by the staff of the Barton Springs/Edward Aquifer Conservation District, the City of Austin Watershed Protection Department, and the City of Austin Wildlands Conservation Department are most appreciated. Nico Hauwert of the City of Austin Watershed Protection Department has been invaluable in all aspects of this note, and his review is much appreciated. In the immediate future, we plan a more detailed report on solution development that will cover the entire Barton Springs Segment of the Edwards Aquifer.

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*Biography*

*William H. Russell is a long-time Austin cave explorer and student of the karst. He graduated from The University of Texas at Austin in 1969 with a degree in geography, concentrating in physical geography. He studied under J. Hoover Mackin and other prominent geologists at the university and has been updating their insights with current data ever since. He has published geologic studies on karst areas in Texas and Mexico. Local publications include a study of the Buttercup Creek Karst in northern Travis and southern Williamson County and an analysis of the Circle C pipeline spill in southern Travis County.*

note

# The Great Debate and a Few Related Recollections

Leslie P. White
*Retired*

The year was 1955, or maybe it was 1956. This narration is drawn entirely from memory, so some rounded edges are to be expected and, I hope, forgiven.

## The Fault Finders

I arrived at the University of Texas in 1951 thinking of possibly majoring in geology. There was a student organization called the Fault Finders. One balmy Saturday they held a field trip to Pilot Knob. We went in an old yellow school bus. The trip was led by the gifted teacher, Dr. Steven E. Clabaugh. All day long he showed us outcrops and revealed the secrets of what had transpired beneath our feet. And we searched for olivine crystals. I remember very clearly returning to my room late in the afternoon with a strong feeling of exhilaration. I cannot put my finger on exactly why. Was it the learning? Was it the insider knowledge of the workings of Mother Nature? I cannot explain it, but I'm sure it was more than the fresh air and exercise. If you are a geologist, you probably know what I'm talking about. That trip did it for me. I began saving my money for a hand lens and a hammer.

After another year or so the Fault Finders failed to open. I don't know if it was a side-effect of one of the cycles we have come to know so well or if a key person or two graduated and it died of natural causes. There was a chapter of Sigma Gamma Epsilon, but it was not available to underclassmen. There was no student chapter of the American Association of Petroleum Geologists. And Austin Geological Society was not yet an idea.

## The University of Texas Geological Society

Four close friends, Eleanor Macha Hoover, Rex White, Bill Ward, and I, thought we could and should get a student geological group restarted. Rex and I had become acquainted through alphabetical seating in Geo 601. Bill Ward was just down the row (the back row, that is) separated from Rex and me by a couple of Wheelers and a Watson. (These names and some other W's remain familiar to me because we would occasionally, at conventions, have a reunion of the back row of Geo 601). I don't remember where Ellie sat, but she was one of just a few women in geology at the time.

It was a simple process to start a student geology group. There was no red tape. No charter, no 501C3 filing. We didn't even get faculty permission because we didn't think to ask. All we had to do was reserve the geology auditorium and have a meeting.

Our first step was to elect officers. Well, it wasn't exactly an election. We four just gathered over a cup of coffee at the Commons and decided. We decided that I would be president and let me quickly say it was a matter of willingness not capability. Ellie was secretary. (Ladies, I'm sorry, but that's how it was then. The secretary was always a girl. Boys couldn't be secretary and girls couldn't be anything else. When I graduated and went to work, men got company cars, but women did not because of something about the ability to operate machinery. My daughter becomes outraged when she hears of these practices. I will tell you like I tell her: "On behalf of my unenlightened generation, I apologize.") I cannot remember what offices Rex and Bill held. I don't think we had a treasurer because we had no money. Ellie remembers that Rex was president, but that was the next year. 1956? 1957? I still have a membership card signed by Rex as president. It has no date.

In our discussions we thought the club might have a better chance of success if it had a more prestigious name than Fault Finders, so we named it The University of Texas Geological Society. Our first meeting was a presentation entitled "What Does a Geologist Do?" We recruited the eminent recruiter, Colonel (Retired) Olin G. Bell of Humble Oil and Refining Co. as our speaker. I recall being surprised to see the geology auditorium nearly full. I thought I was the only one majoring in geology who did not know what a geologist did.

There was another incident that night that is engraved in my mind, one of those embarrassing moments that you never forget. (Larry McMurtry writes that embarrassment is temporary. I disagree. Acclamation is temporary. Embarrassment is forever.) After the meeting I was driving Colonel Bell back to his motel, a spiffy place on lower South Congress. Bill Ward was with us riding in the back seat. I made a left turn in front of oncoming traffic. I knew I had enough room, but Colonel Bell did not. I scared our guest so much that he practically got into the driver's seat with me. A few minutes later we thanked him and let him out. As we drove away I said something like "That's the dumbest thing I've ever done." Bill agreed. He said something like "Yeah, there went that job offer."

We had a talent show. I recall being concerned about our ability to pull this off. And I recall the relief when it became clear that there was an abundance of geologists with entertainment talent willing to perform. And I recall Connie Mayes Dyer tap dancing.

We had a field trip. My only recollection is driving the same old yellow bus through the hill country.

Regretfully, most of the events are as gone as the Llanite dike. (In the 1950s the Llanite dike, with its unique blue cubic quartz crystals, was about waist high in the right-of-way of Highway 16 south of Llano. Today it is at ground level. Perhaps, at certain sites, we should holster our hammers.)

# The Great Debate: Did the Moon Come Out of the Pacific Ocean?

Over the past five decades, whenever a group of geologists of our vintage would gather, nearly always someone would mention the event that has become known as The Great Debate. We would reminisce, laugh, and enjoy it all over again. It was an event which will not and should not

fade into oblivion. I will do my best to record the elements of it that remain alive in my memory as accurately as I can. It is difficult to avoid embellishing the story; on the other hand, it needs none.

The principals of The Great Debate were Professor William Muehlberger and Professor Robert Folk. If you do not know these men, I must say that is unfortunate. They are two remarkable people who will enrich anyone crossing their paths. I will try to introduce them to you.

Bill Muehlberger is a big man who looks even bigger. He has a strong square jaw, a prominent chin, and the perfect posture of a drill sergeant. It would be a mistake to equate his demeanor with this physical description. He is a gentle man. He seems always predisposed to teach as all good teachers are. I did not have courses under Muehlberger, but I had the great pleasure of visiting Solitario with him a few years ago. Over a bowl of chili at a remote camp house, there is no better company. He is a structural geologist, but he is probably best known for his pioneering and lengthy role in training astronauts.

Bob Folk is a smaller man with a youthful face and boundless exhuberance in everything he does. He is, beyond any doubt, a certifiable genius. I had him for sedimentation, his specialty then. I also had him for structural geology which he was called on to teach before Muehlberger's arrival. (To illustrate rock mechanics, he would roll silly putty into a ball and bounce it off the back wall of the classroom—a pretty good arm. Then he would stick it to the blackboard and have us notice how it slowly deformed toward the floor. How could a student ever forget that?) I was taking photogeology when, a few weeks into the semester, the instructor quit. Guess who stepped in to teach photogeology?

Folk taught the first ever in the world carbonate petrography course. The heart of the course was his developing scheme of classification and nomenclature that would revolutionize the understanding of carbonate rocks. (In 1961 Folk's American Association of Petroleum Geologists article on Classification of Carbonate Rocks won Best Paper for the year. Others, seeing the oncoming advancements and taking notice of the clarity and utility of this scheme of classification and nomenclature, began to publish modifications of it. They largely used the same pigeons, just rearranged the pigeon holes and gave the birds new names. One complaint about Folk's classification was that 'micrite' was a new word and too long to easily learn. It is my strong opinion that these later writers did no good for carbonate work and, in fact, only added a component of confusion. O.K. End of tirade. Several years ago I mentioned to Folk this quagmire of classifications and he seemed not at all perturbed by it.) In later years Folk would discover nanobacteria (perhaps simultaneously with another scientist), and I suspect we have not heard the last from these tiny guys. Did I mention he is a genius?

Folk had an affinity for colored chalk in his lecturing. He also had an affinity for knit ties, popular at the time. Knit ties are wrinkle-free but the fabric is heavy and they have low tensile strength, so that as the day wears on they get longer and longer. By the end of one of Folk's energetic late-morning lectures, the end of the tie would be down around the bottom of the zipper and he, the tie, and the blackboard would be covered with colored chalk dust. Unforgettable.

In the 1950s 'plate tectonics' was not yet in the jargon. Continental drift (the forerunning term) was viewed with disdain if not derision. Sea floor spreading, the magnetic patterns, and several other determining factors were not as yet discovered.

It leaked out that Folk was a closet continental drifter. The fact was, he had a smoothly integrated theory which held, in part, that a nearby passing star plucked earth material from what is now the Pacific Ocean basin. The vacancy began to close by the separation and drifting apart of North-South America from Eurasia-Africa. The former 'other side' of the earth reached orbital velocity and there it sits as our moon.

My dim recollection is this: We thought a talk on continental drift would be a great University of Texas Geological Society meeting because it was controversial (You know how students are). Then the idea of a talk evolved into the idea of a debate. The question would be "Did the Moon Come Out of the Pacific Ocean?" I thought this would be harder to pull off than the talent show. The real enabler of the debate was Bill Ward. Bill was working with Dr. Folk on a grain-size analysis paper that they would coauthor. It was Bill who was able to persuade Folk to present and defend his unpopular theory. Bill also solicited Muehlberger to take the other side of the question. And it was Bill, again, who made wonderful posters to advertise the event. The stage was set.

I wish I could remember exactly where the debate was held. It may have been the auditorium of the physics building. Someone told me he thought it was the journalism building. (The memory is as gone as the Llanite dike). The room as I picture it was bigger than the geology auditorium, a capacity of maybe 300 people, and it was very close to full.

It fell to me to introduce the speakers and to state the rules. Folk, first, with 20 minutes for the pro, Muehlberger with 20 minutes for the con. Then Folk with 5 minutes for rebuttal and Muehlberger with 5 minutes for rebuttal. It was all very proper, and I would be time keeper.

I turned it to Folk and he went to the blackboard and went to work, knit tie flailing and colored chalk dust flying. He laid out, as I recall, his convincing story of floating continents. He took the pressure off of me by finishing right on time.

Now Muehlberger. (Many of these recollections are foggy and uncertain. This is not one of them. It is as clear as if it happened this morning. Here is precisely how it went.) Muehlberger came, unhurriedly, to the long black lab table that served as the lectern. He spent what seemed like a long time looking downward at his notes and thoughtfully arranging them. Finally he raised his eyes to the audience and said exactly this: "I feel like the guy who inherited the harem. I know what to do. I just don't know where to start." The audience convulsed, and then convulsed some more. I think if you could visit that room late some night when the campus is quiet, you could still hear laughter reverberating off those walls. Muehlbereger stated his argument, as I recall, based mainly on strength of materials and rock mechanics, punctuated here and there with his remarkable humor. He too finished on time.

Folk had five minutes for rebuttal. He attacked Muehlberger's work in a cloud of chalk dust. A couple of minutes of that and Muehlberger went to the board and took the chalk from Folk and attacked Folk's work. Folk had brought plenty of colored chalk. He grabbed another piece and the debate reached, as they say, a new level. The convulsions of the crowd are now continuous. I am in a quandry. How do you time this? Finally I stood and announced that the time for rebuttal had expired. I have some faint recall of a scattering of boos.

The next may be imaginary. I think Ellie, Rex, Bill, and I huddled quickly and decided, wouldn't you know it, the debate was a tie! More boos.

I have a clear picture of people slowly leaving the room, some almost staggering with laughter or with exhaustion from laughter. The Great Debate was a learning experience that would remain in peoples' minds for years. No one dozed off. No one's mind wandered. It was all things a college lecture should be. And a half century later it is still remembered and enjoyed.

# Epilogue

Not many years after the Great Debate, continental drift, rechristened 'plate tectonics', shed its dubious reputation and became hailed as a major advance in the science of geology. It became a popular topic of technical talks. They always featured the symmetries of the Atlantic side of the globe. After the talk, when I could do so discreetly, I would ask the speaker "What about the other side of the globe?" The answer was usually something like "Well, it is pretty complicated over there." I would think to myself, "Damn right it is. That's where the moon came from."

A few years ago I saw Folk at an AAPG convention where he was receiving another honor. I asked him if he still believed the moon came out of the Pacific basin. He replied that he did not. He said the lunar samples denied it. Isn't it interesting that the astronauts who Muehlberger trained would bring back samples that would settle the debate. On the other hand, continental drift, under a pseudonym, is universally accepted. So the Great Debate was, in fact, a tie.

# Post Script

In the summer of 1956 I happened to stop in at Fuzzy's, a watering hole well-known to geologists located in Llano across the northwest corner from the courthouse square. Before leaving, I stepped into the men's room and there, on the wall, it was in neat, crisp, bold, block lettering, "The University of Texas Geological Society". My chest nearly burst with pride. There we were, immortalized on the restroom wall at Fuzzy's. There were no more worlds to conquer.

A few years later, passing through Austin, I stopped by the geology building and could find no trace of The University of Texas Geological Society. Gone as the Llanite dike.

But we had some great times back in '55. Or, wait, was it 1956?

note

# Beyond Outcrops and Cores—Bridging the Gulf Between Geologists and Civil Engineers in Austin, Texas

C.M. Woodruff, Jr.
*Woodruff Geologic Consulting, Inc.*

*"And beside all this, between us and you there is a great gulf fixed: so that they which would pass from hence to you cannot; neither can they pass to us, that would come from thence."* Luke 16:26, King James Version

## The Great Gulf

Geologists and civil engineers share many common interests and concerns; both disciplines attend to the Earth, albeit from different perspectives. Geotechnical engineers, in particular, focus on the ability of Earth materials to provide stable substrates for man-made structures. Geologists, in contrast, are students of the whole Earth, and their interests span the entire gamut of materials, landforms, and processes—in both academic and applied contexts. Practical matters of ground stability involve such geologic issues as the kind of bedrock beneath a site, including its degree of induration or friability, its texture and fabric, its structural attitude, its porosity and permeability, its weathering attributes; and its typical expression on the landscape. In addition, the type, thickness, and areal distribution of surface materials are of keen interest to geotechnical engineers. Clearly, matters pertaining to both bedrock and surface deposits lie within the domain of geologic research and practice.

Yet, despite overlapping interests, it is as if a chasm (a "great gulf") separates the two disciplines. Much of the gulf stems from miscommunication and from long-term professional habits and expectations that have roots in universities, where institutional barriers commonly separate students of engineering from those in the "arts and sciences." Geologists contribute significantly to communication problems with a copious technical vocabulary that is off-putting to engineers (and to most other non-geologists as well). Besides arcane geologic terminology, some simple words are simply defined differently by geologists and engineers (for example, "soil"). In addition, geotechnical engineers need quantitative data on substrate materials and, in most instances, these demands cannot be met by normal geologic investigations. So the engineer goes his or her own way with testing and analyses. On the other hand, most geologists are only vaguely aware of civil engineering practice, and only a small subset of the geologic profession think that they need information generated by engineers. As a result, most workers within the two disciplines simply disregard one another.

Notwithstanding widespread disregard, the two professions produce information that is potentially of great value to the other, and the main locus of intersection of interests is in cities. The civil engineer needs information presented on geologic maps. Whereas, geologists—especially those mapping in an urban environment—benefit greatly from the three-dimensional perspective provided by geotechnical cores and logs.

In theory, a geologic map should provide key information to the geotechnical engineer. A proper geologic map displays areal limits of bedrock and surface deposits, and it should provide information on material attributes (at least rock type) as well as inferred three-dimensional geometry and structural attributes of bedrock and surface deposits. Alas, not all geologic maps provide this basic information. Problems with using geologic maps as baseline documents for engineering practice stem from several factors: the emphasis on map units as embodiments of geologic time, unwieldy stratigraphic nomenclature, constraints of scale, and failure to delineate surface deposits, to mention only four. Commonly, these problems interact. Scale affects the ability of the map to show precise limits of bedrock features and surface deposits. And the naming of rock units is intimately tied to stratigraphic position, which brings up arcane issues of "time-stratigraphic units" versus "rock units," thereby fomenting confusion among engineers and others. Obviously, some problems with geologic maps originate with the geologists doing the mapping. But more than this, a geologic map is always an approximation, limited by local geologic complexity, extent of exposed rock, access to outcrops, map scale, and time available for mapping. In short, a geologic map is a model of a part of the Earth; such a model requires ongoing refinement and correction.

On the other hand, geotechnical investigations provide information of enormous potential value to geologists, especially in providing third-dimensional views of substrates. This value is especially great in areas in which bedrock is covered by alluvium or other surface materials. Yet certain problems often prevent the use of this information for geologic purposes. First, geotechnical investigations are almost always project-specific. Because of this, there is no consistent attempt to apply the findings beyond limits of the project under consideration. Moreover, many (perhaps most) geotechnical boreholes are cored for clients in the private sector, so that the data are proprietary. In most instances, the core is discarded, and the logs are filed away. Almost always, the information remains unpublished. Even the results of investigations for public-sector projects may meet similar fates: subsurface data are collected on a project-by-project basis, and these data are subsequently filed away and often forgotten. For large projects, attempts may be made to retrieve pertinent subsurface data, but it is difficult to rebuild a data base after the fact. Maps showing the locations of boreholes may be flawed: many boring plans are plotted on base maps that fail to show existing on-ground features (not even topography in some instances). Often, these location maps are mere schematic illustrations, and many contain the notation "NTS" (not to scale). Tied to the lack of precision in plotting map locations is the failure of many geotechnical logs to indicate ground elevations of the boreholes. Clearly, logs without a precisely plotted location and without ground elevation are of scant value to a geologist.

In short, the geotechnical engineer needs the geologist's map. And the geologist needs the information generated by geotechnical drilling. Such a drilling project provides the geologist with invaluable perspectives (and sometimes actual samples) of the third dimension. Given these subsurface data, a geologist is able to correlate between boreholes. In this way, structures and other discontinuities may be mapped, and these interpretations may be of great value to the

engineer. Valuable interpretations derived by one discipline from the work of the other provide possible bridges across the "great gulf" of flawed communication. It is important for each discipline to be aware of the expanded audience for their professional products (maps and interpretive logs). To explore specific ways of bridging the gulf, examples are presented from the urban environment of Austin, Texas. The focus here is on the geologic underpinnings of Austin, hence, the discussion focuses on geologic mapping of this area.

# Austin, Texas—A Case Study in Surface Mapping and Subsurface Correlation

As pointed out by Flawn (1970), the geologic setting of Austin is dominated by two natural phenomena: the Balcones Fault Zone and the Colorado River. The fault zone has resulted in the abrupt juxtaposition of strata having markedly different properties. And of course, the prevailing northeast-southwest trend of the major faults provides a structural grain that is seen along the Balcones Escarpment and elsewhere in the Austin area. The Colorado River and its tributaries have eroded the landscape into hills and valleys, but these streams also have deposited diverse thicknesses of alluvium at various places on the landscape. Thus, the two key aspects of the local geologic environment illustrate the mutual dependence between local practitioners of geology and geotechnical engineering in Austin: the abrupt discontinuities in bedrock units within the fault zone place a high premium on the mapping abilities of the geologist. And uncertainties posed by the faulting, as well as the widespread cover by alluvial deposits, place a premium on subsurface information gained from borings drilled and cores extracted and analyzed during engineering investigations.

The map prepared by Garner and Young (1976) provides an excellent overview of the geologic setting of the Austin area. It clearly shows the sequence of Cretaceous bedrock units, the structural grain along this part of the Balcones Fault Zone, and the approximate areal extent of Quaternary surface deposits. This map, however, is limited by its scale (1:62,500, or roughly 1 inch to a mile) and by the uneven thickness and variable mappability of stratigraphic units. Despite these problems (which will be discussed further), copies of the Garner and Young (1976) maps are found on the walls of most geotechnical firms in Austin. It is used as a first approximation for engineers ascertaining general conditions at any given site, and it provides tentative information on substrate for project-planning purposes (before drilling and testing).

Scale limitations of the Austin geologic map are obvious. Most geologic mapping is done using the U.S. Geological Survey's 7.5-minute Quadrangle topographic series, and the geologic field work underlying the map by Garner and Young (1976) map was done on this base at a scale of 1:24,000 (see Rodda and others, 1970). This scale is appropriate for the uses intended for most area-wide geologic surveys. However, for purposes of engineering design, the 1:24,000 scale is woefully inadequate, as most engineering site plans are presented at scales of 1:600 (1 inch = 50 feet) or larger. Thus, the limitations of published geologic maps are apparent to the very same engineers posting the Austin Geology map on their walls and using it for initial project planning. But detailed geotechnical investigations afford many opportunities to refine the published map. The late Frank Bryant, noted local geotechnical engineer, maintained ongoing revisions of the Garner and Young (1976) map, based on findings from his many site investigations. Sad to say,

the “great gulf” between geologists and engineers prevents a ready means of transmitting this new-found information back to the geologic community.

Besides scale, other problems with using the geologic map in an engineering context stem from the formulations and definitions of geologic map units in an area. This problem is even more difficult to rectify than that of map scale because of the historical constraints regarding map units (including the rules of stratigraphic nomenclature). For example, the stratigraphic section presented in the explanation of the Garner and Young (1976) map comprises rock units whose nomenclature dates back to investigations by pioneering Texas geologists (for example, Hill, 1899–1900). This bedrock section was codified in part because of the “reality” of composition and thickness of stratigraphic packages and partly as a result of the manner in which the rock section was initially described (commonly based on paleontology) at least 100 years ago. Thus, the local rock units consist of (from bottom to top): two thick limestone units (Glen Rose and Edwards) separated by thinner sequences of carbonate-rock units (Walnut and Comanche Peak); above these there is a relatively thin sequence of rock units that alternate between limestones and claystones and shales (Georgetown, Del Rio, Buda, and Eagle Ford), which are overlain by several hundred feet of relatively soft limestone and “chalk” (Austin), which, in turn, is capped by thick sequences of claystone (Taylor and Navarro).

These Cretaceous strata strike northeast-southwest and dip gently to the southeast, so older units occur on the west side of the Garner and Young (1976) map with progressively younger units to the east. However, the areal relations among these strata are significantly affected by faults. The general trend of the Balcones Fault Zone extends parallel to depositional strike of bedrock in the Austin area, and this creates ambiguity with formational contacts. That is, for some rock units it is difficult to discern whether a contact is faulted or is a normal stratigraphic sequence. But besides this, an apparent anomaly is seen in the middle reaches of the map. There, a complex mosaic pattern of fault displacements occurs among the relatively thin sequences comprising Georgetown, Del Rio, Buda, and Eagle Ford formations. No such mosaic pattern is mapped either higher in the section (within the Austin Group or the Taylor/Navarro) or lower (in the Edwards). Likewise, no similar pattern is noted west of the Mount Bonnell Fault. The question arises as to whether such a detailed pattern exists in other areas but is not discerned, owing to thicker sequences of similar rock types. Or perhaps the alternating sequences of clay shales and limestone strata were more prone to small-scale dislocations, thus imparting intricately broken structural patterns that do not occur elsewhere.

These hypotheses could be tested, using geotechnical borehole data along with detailed examination of aerial photos and follow-up field work. But to do this, it would be necessary to correctly correlate between cores extracted from the thicker units. That task, however, is fraught with problems because of difficulties with discerning appropriate “marker horizons” for reference in subsurface correlations. Now the Austin Chalk has been elevated to Group (or Division) status and comprises seven formations (Young, 1985). Although bedrock characteristics make up part of the defining attributes of these seven formations, changes in fossil assemblages are also important aspects of these units. Moreover, the recognition of the various units composing the Austin Group/Division depends on features expressed in outcrops. Subtle weathering attributes seen in exposed rock are not evident in cores, so that the formations composing the Austin Group/Division are generally not recognized by geotechnical engineers. Likewise, correlation of these units in cores poses challenges to geologists. Instead, local opportunities for correlation are provided by bentonite beds, but these intervals are not consistent

in thickness (or in number) within even relatively small areas. In short, precise subsurface correlations depend on penetration of formation boundaries that are well expressed in cores. Thus, for extensive projects (such as tunnels or other linear infrastructure systems), part of the engineer's planning must include key borings designed to reach "target horizons" for correct correlation. Such borings will likely be deeper than others, so that additional budget must be proposed and justified.

Other geologic units besides the Austin Chalk pose similar problems with subsurface correlation on the basis of cores. Much effort is needed by both geologists and engineers in attempting to correlate recognizable intervals within the "blue clay" sections that comprise the Taylor and Navarro groups. Likewise, boundaries of the various members composing the Edwards Group pose challenges, owing to overall prevalence of dolomite throughout the local section. Moreover, within this dolomitic limestone, certain lithologies recur repeatedly. For example, grainstone sequences are not limited to the "grainstone member," a hydrostratigraphic unit mapped by the U.S. Geological Survey in the Edwards outcrop (Small and others, 1996). In addition, wackestone intervals are seen to recur repeatedly in Edwards' cores but are not readily seen in most outcrops. Compounding these problems are local effects of karstification, including extensive microkarst zones (and attendant low core recovery) as well as local large voids, some of which are filled by secondary materials—for example, flowstone or clay. For the voids especially, our knowledge often depends on the care exercised by the driller, who (it is hoped) will record the magnitude of abrupt drop of the kelly; otherwise, the only indication of a void is the missing interval of core (which can result from various causes).

# Conclusions

Geologists and civil engineers perform their professional tasks using different methods and, commonly, differing views of the world. But both disciplines extract information from the Earth. And it is altogether too common that—owing to lack of communication—a "gulf" exists that prevents sharing of data between geologists and engineers. Both groups would benefit from a measure of détente. Engineers' logs derived from cores and geologists' maps would be improved if increased professional interactions were the norm. Several urban infrastructure projects are underway presently in Austin, and these offer significant opportunities for geologists and engineers to use the information generated by the other to produce a better "model" of reality in this complex urban environment. Perhaps we geologists should recruit like-minded engineers to attend our field trips. Perhaps, in turn, we geologists might be invited to view selected cores from notable local sites. By doing that, the "gulf" may be bridged—at least in part.

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*Charles M. Woodruff, Jr. received his B.A. and M.S. degrees in geology from Vanderbilt University and his Ph.D. from The University of Texas at Austin. He worked as a research geologist for The University of Texas at Austin from 1972 until 1983. Since 1983 he has been an independent consulting geologist, and since 2001 he has been a Senior Lecturer in the Department of Civil Engineering at The University of Texas at Austin.*

# austin geological society bulletin

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**Faults and Fractures in the Balcones Fault Zone, Austin Region, Central Texas** by E. W. Collins and S. E. Laubach, Coordinators with an experimental demonstration by B. C. Vendeville and a summary of the regional fracture patterns by W. R. Muehlberger. Includes road log. Guidebook 13, 1990, reprinted 2004, 34 p. **AGS 013, $12.00**

**Water Quality Issues for Barton Creek and Barton Springs** by D. A. Johns, Field Trip Leader. Guidebook to field trip containing road log of eight stops, excerpts from the report of the Barton Springs Task Force to the Texas Water Commission, and five articles on Barton Creek and Barton Springs. Guidebook 14, 1991, 95 p. **AGS 014, $15.00**

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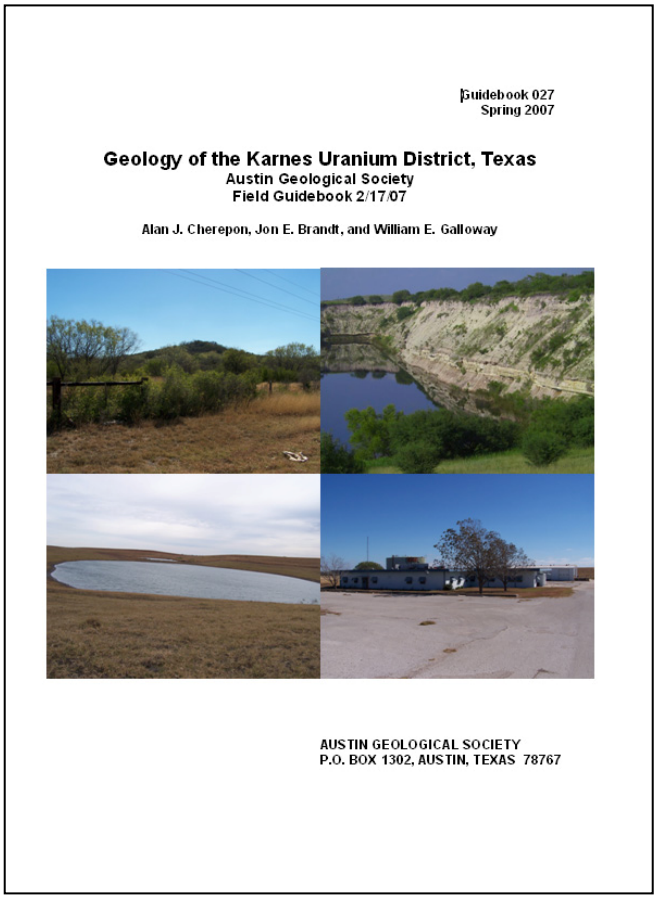
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Alan J. Cherepon, Jon E. Brandt, and William E. Galloway

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- O Renewal Student Member ($5 dues/year)
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**We invite you to become a member of the Austin Geological Society and share in our programs. Your membership will bring you:**

- notice of AGS meetings with speakers.
- notice of AGS field trips to sites of geological interest.
- social gatherings of geological professionals in the Austin area.
- a monthly newsletter to keep you informed of Society and regional news of interest to geologists.
- the opportunity to become acquainted with other geologists in the Austin area.

**The requirements for membership are:**

- To be eligible for Active Membership, an applicant shall have a degree in geology from a recognized college or university, or the equivalent experience, or have been actively engaged in the application of geology or related scientific or professional work for a minimum of two years.
- Consideration of Honorary Membership shall be based on continued dedication and service to the Austin Geological Society. Honorary members shall be selected by the Executive Board. Any Active Member may submit the name of an individual to the Executive Board for consideration as an Honorary Member.
- Any person who is a student in good standing, studying for a degree in geology or related science, is eligible for Student Membership. Student Members shall not be eligible to vote or hold elective office.

**AUSTIN GEOLOGICAL SOCIETY**

**CONSTITUTION**

Approved October 7, 1965
Revised December 21, 1990
Revised August 14, 1995
Revised May 1, 2000

## ARTICLE I

### Name and Objectives

Section 1. This organization shall be named "Austin Geological Society."

Section 2. The objectives of the Society are:

(1) to stimulate interest in and promote advancement of geology;
(2) to facilitate discussion and dissemination of geologic information;
(3) to encourage social and professional cooperation among geologists and associated scientists;
(4) to maintain a high professional standing among the members; and
(5) to enhance public understanding of the professional activities of the members.

## ARTICLE II

### Membership

Section 1. The members of the Society shall consist of persons concerned with the science and practice of geology.

Section 2. Various classifications of memberships and qualifications thereof shall be established by the Bylaws of the Society.

## ARTICLE III

### Government

The government of the Society shall be vested in five (5) elected officers and an Executive Board. The composition of this government, the manner of selection, the terms of office, the specific duties, responsibilities, and other matters relevant to such bodies and officers shall be as provided in the Bylaws of the Society. Any responsibility and authority of government of the Society not otherwise specified in these governing documents shall be reserved for the Executive Board.

## ARTICLE IV

### Amendments

Amendments to this Constitution may be proposed at any time by petition signed by at least 20 percent of the Active Members or by the Executive Board. Adoption of such amendments shall be by ballot in which approval is given by at least three-fourth of the total number of Active Members. There shall be an intervening Regular Meeting before the balloting and subsequent to the submission of the amendment.

## ARTICLE V

### Dissolution of Society

In the event it should be deemed advisable to dissolve the Society, all assets at the time of dissolution shall be donated to a worthy geologic cause, as selected by the Executive Board.

## ARTICLE VI

### Bylaws

The Bylaws, consisting of six (6) articles as appended hereto, are adopted and may be amended, enlarged, or reduced as provided in the Bylaws.

**AUSTIN GEOLOGICAL SOCIETY**

**BYLAWS**

**ARTICLE I**

**Membership**

Section 1. The membership of this organization shall be made up of Active, Honorary, and Student Members.

(1) To be eligible for Active Membership, an applicant shall have a degree in geology from a recognized college or university, or the equivalent experience, or have been actively engaged in the application of geology or related scientific or professional work for a minimum of two (2) years.

(2) Consideration for Honorary Membership shall be based on continued dedication and service to the Austin Geological Society. Honorary members shall be selected by the Executive Board. Any Active Member may submit the name of an individual to the Executive Board for consideration as an Honorary Member.

(3) Any person who is a student in good standing, studying for a degree in geology or related science, is eligible for Student Membership. Student Members shall not be eligible to vote or hold elective office.

Section 2. Any member who is in arrears of dues or legally incurred indebtedness to the Society shall be suspended from the Society. The Executive Board shall restore former membership status to any such suspended member when the indebtedness has been liquidated.

Section 3. All Active, Honorary, and Student Members shall be guided by the highest standards of business ethics, personal honor, and professional conduct. Any member who, after proper investigation by the Executive Board, is found guilty of violating any of these standards of conduct may be admonished, suspended, allowed to resign, or expelled from membership at the discretion of the Executive Board.

Section 4. Applicants for membership shall submit an application and dues to the Treasurer. Membership applications shall include the following information:

(1) Professional affiliation,
(2) Education, and
(3) A statement of how the prospective member qualifies for membership.

New members shall be announced in the next newsletter and introduced to the Society at the next meeting.

## ARTICLE II

### Dues and Special Assessments

Section 1. The annual dues for Active Members and Student Members of the Society shall be established at the beginning of each administrative year by the Executive Board. Dues shall be payable on or before November 1 each year. No dues shall be required of Honorary Members.

Section 2. Dues for new members who join the Society after the beginning of the administrative year shall be prorated according to the quarter of the administrative year.

Section 3. Members who are in arrears for dues and/or special assessments for a period of three (3) months shall be deemed suspended and may be dropped from the rolls at the discretion of the Executive Board. Such former members may be reinstated by the Executive Board upon payment of dues and/or special assessments in arrears plus a reinstatement fee of 25 percent of the amount owed.

## ARTICLE III

### Officers

Section 1. The officers of this organization shall be the President, President-Elect, Vice-President, Secretary, and Treasurer. The tenure of these officers shall be one (1) administrative year.

Section 2. The duties of the President shall be to preside at all meetings, call Special Meetings, appoint such committees as are not provided for in the Bylaws, and, jointly with the Secretary and Treasurer, sign all written contracts and other obligations of the Society. The President shall assume the duties of Chairperson of the Executive Board and supervise the business of the Society. The President shall also be responsible for making arrangements for a meeting place for Regular Meetings and providing for an annual audit of financial records.

Section 3. The duties of the President-Elect shall be to participate in Executive Board meetings and serve as understudy to the President. The President-Elect will assume the office of the President the following year. The President-Elect shall also serve as Chairperson of the Election Committee.

Section 4. The duties of the Vice-President shall be to assume the office of president when a vacancy for any cause occurs and assume the duties of the President during the absence or disability of the President. In addition, the Vice-President shall serve as Chairperson of the Technical Program Committee.

Section 5. The duties of the Secretary shall be to keep the Minutes of all meetings, to attend to all correspondence and press notices, to receive and be custodian of all documents and papers of the Society, and to notify all Executive Board members of each Executive Board Meeting. The Secretary shall also serve as Chairperson of the Newsletter Committee. The Secretary, jointly with the President and Treasurer, shall sign all written contracts and other obligations of the Society and shall assume the duties of the President in the absence of the President and Vice-President.

Section 6. The duties of the Treasurer shall be to receive and disburse all funds as authorized by the Society, to keep accurate accounts thereof, and to submit annually a report of the

Treasurer's records for auditing. The Treasurer shall be present or delegate a substitute to be present at each Regular Meeting to collect monies and membership applications. The Treasurer, jointly with the President and Secretary, shall sign all written contracts and other obligations of the Society, and shall assume the duties of the President in the absence of the President, Vice-President, and Secretary.

Section 7. The Executive Board shall consist of the President, President-Elect, Vice-President, Treasurer, and the last available past President. The Executive Board's duties shall be to appoint officers to fill vacancies occurring during the administrative year, except the office of President to which the Vice-President shall succeed; and to have general supervision of the organization.

Section 8. The election of officers shall be held at the Annual Meeting. Nominations shall be made by the Election Committee consisting of the President-Elect and at least two members appointed by the President-Elect. This Committee shall nominate two or more candidates for each elective office to be announced in the Society Newsletter prior to the Annual Meeting. At the Annual Meeting, additional nominations may be made from the floor following the report of the Election Committee. The Election Committee shall be responsible for preparation, distribution, and collection of the ballots at the Annual Meeting, and the tabulation of the results of said balloting. The committee shall present the results of the balloting to the President of the Society during the Annual Meeting so that the newly elected officers may be presented to the Society. Voting shall be by secret ballot. Ballots shall be distributed during registration at the Annual Meeting and shall be returned to the Election Committee upon completion. If none of the candidates for a particular office obtains a majority of the votes cast, the candidate with the least number of votes shall be eliminated and a second ballot taken. If there is a tie between two candidates, a second ballot shall be taken at the Annual Meeting. If, after the second ballot, there is still a tie, the winner shall be decided by the flip of a coin.

## ARTICLE IV

### Standing Committees

Section 1. There shall be the following Standing Committees within the Society:

- Publications Committee,
- Technical Program Committee,
- Newsletter Committee,
- Field Trip Committee,
- Membership Committee,
- Web Committee,
- Election Committee, and
- Awards Committee.

The President shall appoint a Chairperson to those committees not already chaired by an officer. These appointments shall be for one administrative year. The Chairperson of a Standing Committee may, in turn, appoint any additional members in good standing with the Society to his or her committee.

In addition to the aforesaid standing committees, there is the Nominating Committee, as previously set forth in Article III, Section 8, of the Bylaws. The President may appoint any special committees as the Executive Board may authorize.

Any Committee Chairperson or member may be removed and replaced by a new appointee upon majority action of the Executive Board.

Section 2. The purpose of the Publications Committee is to oversee the sale of Society publications and assist in the publication of any other manuscripts or documents the Executive Board may authorize.

Section 3. The function of the Technical Program Committee is to provide a program for the Regular Meetings of the Society and to make necessary arrangements for that program.

Section 4. The function of the Newsletter Committee shall be to prepare and mail a newsletter to serve as an announcement of Society Meetings.

Section 5. The purpose of the Field Trip Committee shall be to organize the Society field trips on a suggested schedule of one in the fall and one in the spring.

Section 6. The Membership Committee shall encourage membership, assist the Treasurer and Newsletter Chairperson, maintain a list of active members, and prepare the Society Directory.

Section 7 The Web Committee shall be responsible for the design and upkeep of the Society Web page.

Section 8. The Awards/Scholarship Committee shall nominate and recommend award and scholarship candidates to the Executive Board.

## ARTICLE V

## Meetings

Section 1. The meetings of the Society shall be of three classes: Regular, Executive Board, and Annual.

Section 2. The Society shall hold at least one Regular Meeting each month from August through April except that, by vote of the Executive Board, additional Regular Meetings may be held or Regular Meetings may be discontinued for a period not to exceed three months. The appropriate time and place for Regular Meetings shall be selected by the President or a delegated Committee.

Section 3. Executive Board Meetings shall be held at such times and places and for such purposes as the Executive Board deems necessary and as announced by the President.

Section 4. The Annual Meeting shall be held during the month of May at a place and time designated by the Executive Board. The purpose of this meeting will be to complete the business of the administrative year and shall include the following order of business:

(1) Report of the Executive Board, the President, the Treasurer, and the Standing Committees. Standing Committees may be considered with the report from the President.
(2) Old or unfinished business.
(3) New business.
(4) Election of new officers.

(5) Program.
(6) Presentation of new officers.

Section 5. The administrative year shall be from August 1 of one year to July 31 of the following year.

## ARTICLE VI

### Awards

Section 1. The Awards Committee shall submit recommendations to the Executive Board for the Public Service Award, the Distinguished Service Award, and for scholarships to be awarded by the Society.

Section 2. The Public Service Award shall be given to recognize contribution of members to the Society to public affairs and to encourage geologists to take a more active part in such affairs. The recipient shall be a member of the Society, but may be in any class of membership. This award may be given without regard to previous awards. Granting the award in any year shall be discretionary.

Section 3. The Distinguished Service Award shall be given to members who have distinguished themselves in singular and beneficial long-term service to the Society. The emphasis shall be on long-term and, at the same time, meaningful service to the Society. The term singular does not necessarily mean without precedence, but rather that the activity be specific as distinguished from general service. More than one member of the Society may be considered in any one year for the award, but Honorary Members should generally be excluded.

Section 4. Scholarships shall be awarded from an endowed scholarship fund. The Executive Board shall select scholarship recipients from candidates recommended by the Awards Committee. Granting scholarships in any year shall be discretionary.

## ARTICLE VII

### Amendment to Bylaws

Amendments to the Bylaws shall be made by vote of three-fourths of the Active Members present at any Regular Meeting, provided that due notice of the proposed amendment has been submitted to the members of the Society at least two weeks in advance of the date on which the ballot is taken, and provided a quorum (twenty-five percent of the Active Membership) is present at said meeting.