The Bulletin
Houston Geological Society

Volume 46, Number 4 December 2003

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about the cover: Earth Science Week, October 11-19 was observed in Texas and the nation. A video wall at the Wiess Energy Hall, Houston Museum of Natural Science shows the creation of the Earth and solar system with a young particpant at Family Earth Science Festival, October 11, 2003. *Photo by A.E. Berman*

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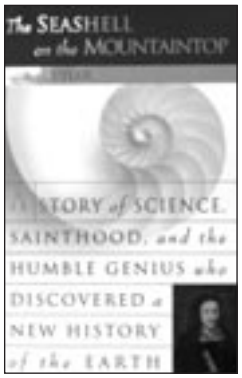

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President's Letter

by Craig M. Dingler

Talking Turkey Over Gumbo and Tex-Mex

Seasons Greetings!

One of the more interesting aspects to being the HGS President is the interaction I have with our umbrella organizations, the Gulf Coast Association of Geological Societies (GCAGS) and the American Association of Petroleum Geologists (AAPG).

GCAGS News

During the Gulf Coast Association of Geological Societies (GCAGS) annual convention in Baton Rouge last October, several actions took place at the Board of Directors meeting that affect the HGS. First, GCAGS will keep its control center in Austin. GCAGS had contracted to lease space within the HGS office, but it was unable to find any office staff who fit with the pay scale offered and schedule needed. GCAGS will locate at the Bureau of Economic Geology complex, with free office space. It was also reported they had three candidates for office manager. With the GCAGS located at the BEG, there should be plenty of UT-Austin student volunteers to help when needed. We are sorry that the GCAGS headquarters will not be in Houston, but we must recognize the Austin deal was too good to pass up.

One of the more interesting aspects to being the HGS President is the interaction I have with our umbrella organizations, the Gulf Coast Association of Geological Societies (GCAGS) and the American Association of Petroleum Geologists (AAPG).

GCAGS also voted to drop its request for proportional representation on the AAPG Advisory Council, which it proposed several years ago. This proposal had a snowball's chance in Houston of getting approved through the whole AAPG House of Delegates, so GCAGS decided to rescind the proposal. Tim Rynott and others will try to work up alternative means to ensure the Gulf Coast societies have fair numbers of AAPG officer nominations and member awards.

The GCAGS annual convention schedule is set for the next five years. Next fall the meeting will be in San Antonio (please see the call for papers on page 24 of this Bulletin). The following year it moves to New Orleans, with the theme "Gulf Coast geological gumbo—a recipe for success." Then it's on to Lafayette in 2006, and Corpus Christi in 2007. The next GCAGS convention in Houston will be in the fall of 2008. This should give us a few months to recuperate from the AAPG annual meeting in Houston the spring of 2006!

Finally, it was my pleasure to be on hand during the convention's opening ceremony as HGS members Dave Rensink and Charles Sternbach were awarded GCAGS Distinguished Service awards. Dave graciously accepted the award for Charles, who was unable to attend. (Something about needing to be at the Jordan Oil and Gas headquarters in California during the grape crush!) Congratulations to both; your recognition was long overdue!

AAPG Awards

HGS members will receive awards at the AAPG annual meeting that will be held in Dallas next April from the 18th through the 21st. Martha Lou Broussard **President's Letter** *continued on page 7*

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and Stewart Chuber will receive Honorary Membership awards. Deborah Sacrey, Barry Katz, and Pete Gray will receive Distinguished Service awards. Please join me in congratulating these outstanding HGS members who give so much back to our profession.

Member Recognition

Speaking of awards, every spring the HGS Executive Board goes through the process of selecting and nominating members for awards. In addition to HGS awards, there are GCAGS and AAPG award nominations that are considered. This process is one of the more gratifying tasks that board members perform. It's actually quite fun. However, with such a large society, the board undoubtedly overlooks some HGS members that are due proper recognition. If you know of someone who is deserving of an honor, please do not hesitate in contacting either me or HGS past-president Denise Stone, Nominations Committee Chairwoman. I can't think of a nicer gift that you could offer during this season of giving!

To you and yours—Happy Holidays, everyone!

Consider Running for AAPG Delegate

Houston candidates are now needed to run for the office of AAPG Delegate in the election to be held in early 2004. If you are interested in having a leadership role in the business and future course of AAPG, and contributing your ideas and your voice toward AAPG's business agenda, consider running for Delegate. This service role offers opportunities for networking and making a meaningful impact on the continuing efforts of AAPG. If you would enjoy representing your colleagues to AAPG, and representing AAPG to your colleagues, this role is for you.

The House of Delegates is the legislative body of AAPG. Delegates participate in the legislative process during the annual meeting of the entire House of Delegates, which takes place at the AAPG Annual Convention. During their three year term, Houston Delegates meet during lunch monthly to process new member applications, network and manage the business issues at hand. The group is fun and energetic, representing many companies, geoscience roles and practices.

New members with fresh viewpoints are welcome. If you are interested please contact Denise M. Stone (dmstone@pdq.net, 281-497-4717) or Martha Lou Broussard (mlbrou@rice.edu, or 713-665-4428) for further information or to volunteer.

Editor's Letter

by ***Diane Yeager***

Inside The *Bulletin* The People Who Make it Happen

Have you ever wondered who works on the *Bulletin* and what we do to get the *Bulletin* together? I thought this may be a good time of the year to introduce the society to these people and to simply thank them for their unwavering dedication in making this publication possible.

Getting the *Bulletin* together starts with the committee chairs, directors, and board members. Paul Babcock, Linda Sternbach, Sherri Cronin, and Glenn Lowenstein work diligently throughout the year to line up speakers for their respective dinner and lunch meetings. Once they get their speakers to commit to a talk, they work with them to develop abstracts and biographies. They make certain that these documents are on the editor's desk 50 days prior to the date of publication. I received this issue's abstracts and bibliographies by October 15. These individuals do an exceptional job in keeping the deadlines to the editor, for which I am very appreciative.

My thanks go to everyone involved for making this effort fun and rewarding.

Art Berman, Editor Elect, has managed to do virtually everything at times. In case you haven't noticed, Art's name is on almost every photograph credit including the feature article on Earth Science Week. Art has exceptional photographic talent and a long history as the HGS's photographer. Fortunately, his volunteer duties as Editor Elect have not dissuaded him from continuing to submit exemplary photographs. Your *Bulletin* will be in good hands next year.

Once we have the articles, abstracts and other materials for *Bulletin* publication, we transfer them to a CD. Copies are compiled in a three-ring binder in the order in which they will be published. We give both the CD and the binder to Lisa Krueger of Krueger Design. Lisa is the graphic designer for the *Bulletin*, and she repeatedly goes beyond the call of duty. Lisa converts the files to her layout software and sets up the pages with the advertisements. Thankfully, Lisa's efficiency affords us a little more time in getting the initial contents and reviews to her. Lisa delivers drafts to the editor, reviewers, and advertisement manager Lilly Hargrave while maintaining constant communication with the editor. Lisa understands the *Bulletin* layout and makes any necessary changes. Thanks, Lisa!

The *Bulletin* offers more than technical articles and speaker abstracts. The *Bulletin* contains more than 50 advertisements each month. Lilly Hargrave manages the advertisements and the advertisement space allocation. In case you haven't had the opportunity to meet Lilly, she works in the HGS office. Lilly compiles the advertisements and provides them to Lisa. She reviews the draft *Bulletin* to ensure that the advertisements are presented per the advertisers' expectations and that two competing firms are not presented on adjacent pages. Lilly tracks the invoicing and submits a monthly report to the editor. This is Lilly's first year with the HGS, and she has proved to be a valuable asset to the *Bulletin*.

Once Lisa compiles the draft she distributes a copy to each reviewer. Our primary grammarian is Elsa Kapitan-White, whom I call the "Jewel of the Bulletin." She has received drafts with only a day to spare and without a complaint she manages to review the document thoroughly and provide her comments by the next day. I have submitted late articles to Elsa via e-mail after her draft review and she still manages to fit the review into her busy schedule. Elsa spoils us, and without her we would not be able to push deadlines.

Review comments are submitted to the editor. The editor compiles the comments and provides **Editor's Letter** *continued on page 53*

Tuesday, December 9, 2003

Rudy Lechners Grill • Woodlake Square, Gessner at Westheimer
Social 5:30 p.m., Dinner 6:30 p.m.

Cost: $25 Preregistered members; $30 Nonmembers & Walk-ups

Make your reservations now on-line through the HGS website at www.hgs.org; or, by calling 713-463-9476 or by e-mail to Joan@hgs.org (include your name, meeting you are attending, phone number and membership ID#).

Engineering and Environmental Dinner Meeting

*by **Dr. William S. (Bill) Hitchcock***
W. S. Hitchcock, Inc.

The Selection of an Environmental Laboratory: What to Do and What Not to Do

Successful laboratory programs depend heavily on the shared understanding of the end data user's needs. The person responsible for selecting the laboratory must understand the data user's needs and communicate those needs to the laboratory. Laboratory selection cannot be made until the data quality objectives have been established.

The end data user's needs determine the data quality objectives (DQOs). The DQOs are used to select the level of required performance (LORPs). The LORPs include methods, detection limits, and quality control limits. Not all laboratories can meet the levels that you may require, or even perform the analytical methods you may require.

Determination of the qualifications of a laboratory is obtained through a recent audit performed by a qualified chemist who has a clear understanding of your DQOs. The audit(s) should be augmented with performance evaluation samples, which are samples of known concentration that are sent to the laboratory for analysis and reporting. Their analysis provides a check of both the laboratory's equipment capabilities and its quality control program. The reporting process is also reviewed during this test to see if the laboratory does indeed deliver all the required data in a usable format, and in a timely manner.

The two most common causes for failure of an analytical program are failure to clearly define DQOs and failure to clearly communicate them to the laboratory. Expectations, such as LORPs deliverables, schedules, and special quality control needs ,must be clearly communicated with the laboratory. Using a data form that can serve as a checklist is highly recommended. Once you have identified two or three labs that can and will do what you need, then price can be considered. The saying "You get what you pay for" generally applies at this point in an evaluation. If a laboratory has substantially lower rates, the auditing chemist might discover that is due to a cost-cutting practice that would render the data results unsuitable for your use. However, under some circumstances it is possible to lower prices by leveraging other projects. ■

Biographical Sketch

Dr. William S. (Bill) Hitchcock has 30 years of experience in environmental chemistry, serving CONOCO and DuPont Environmental in the 1980s and 90s. He presently serves as President of W. S. Hitchcock, Inc., which provides consulting on chemistry, environmental chemistry, data validation/review, and sampling. With more than 20 years' experience, he has managed the quality of chemical data. He also serves as Principal Chemist of Environmental Litigation Associates, is a Primary Lecturer for the Institute of Environmental Technology (http://www.ela-iet.com/), and provides litigation support and expert testimony in chemistry and environmental chemistry to industry and the legal community.

Monday, December 15, 2003 HGS N. American & International Explorationists
Joint Dinner Meeting

Westchase Hilton • 9999 Westheimer
Social 5:30 p.m., Dinner 6:30 p.m.

Cost: $25 Preregistered members; $30 Nonmembers & Walk-ups

Make your reservations now on-line through the HGS website at www.hgs.org; or, by calling 713-463-9476 or by e-mail to Joan@hgs.org (include your name, meeting you are attending, phone number and membership ID#).

by ***Frank J. Peel,***
BHP Billiton Petroleum
Houston, Texas

Styles, Mechanisms, and Hydrocarbon Implications of Syndepositional Folds in Deepwater Fold Belts: Examples from Angola and the Gulf of Mexico

This presentation combines recent published material with new ideas to provide a review of how the structural geology of deepwater fold belts influences the distribution of hydrocarbons within them. How do deepwater fold belts differ from orogenic fold belts? What factors control the location of the fold belt? What is the significance of early-formed precursor folds? Why are these factors important in the exploration for hydrocarbons?

Compressional fold belts in deepwater settings have been a major focus of recent exploration and appraisal activity

First, we consider the significant differences between passive-margin and orogenic fold belts, then, the application of Coulomb wedge theory to passive margins (to explain where and why fold belts form), and lastly, explore a critical factor—whose significance has only recently been recognized— namely the influence of early-formed folds on the later-formed large structures, and how hydrocarbons are trapped within them.

Part 1: Comparison of passive margin fold belts with orogenic fold belts

Fold and thrust belts occur primarily in two settings: either linked to an orogenic belt forming due to plate convergence, or in the compressional toe of a system of gravity-driven movement on passive margins. While mixed-mode fold belts also exist, and other scenarios for fold belt formation are also observed, it is instructive to compare and contrast the two end members and consider the implications of the differences for the hydrocarbon systems, which can trap in either setting.

Orogenic fold belts

The ultimate driving mechanism of orogenic fold belts (including accretionary prisms) is relative plate movement. The rate of convergence is effectively fixed, and the main variable affecting the rate of movement in the frontal thrust belt is the partitioning of shortening between the frontal thrust system and contraction within the body of the orogenic belt. Shortening occurs whether or not there is a good décollement. The nature of the décollement does, however, have a strong influence on the structural style. The total shortening in the orogenic fold belt can be 100s of kilometers, and, as a result, most of the thickening of the orogenic wedge occurs by tectonic thickening of the accreted mass.

Passive-margin fold belts

The ultimate driving force of passive-margin fold belts is gravity. This may take the form of gravity sliding, driven by the existing slope of the margin, plus continued tilting (as seen in the outer Kwanza Basin, and the GOM Cretaceous/Paleogene strata), or of gravity spreading of the sediment wedge (like in the Niger Delta, Africa, and Neogene GOM). The rate-limiting factors are the rheology of the wedge, décollement level, and the rate of sediment input to the shelf and upper slope. As a result, passive-margin fold belts are commonly intimately linked to the pattern of depositional systems on the margin.

While most passive-margin fold belts shorten at slower rates than orogenic fold belts, there are no upper boundaries to the possible rates of movement. If the conditions for mechanical failure of the margin are not achieved, no movement will occur; passive-margin fold belts may move continuously, episodically, or not at all. A passive-margin fold belt can develop only where there is a good décollement layer present. This commonly consists of salt or overpressured mud. The total shortening in passive-margin fold belts is limited by the dynamics of the system and is typically 5–50 km, more commonly toward the low end of that range. As a result, the majority of the thickening of the transported wedge occurs by

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deposition on top of the wedge, rather than by structural thickening.

Part 2: Dynamics of "passive" margins—what controls the location of passive-margin fold belts

Simple Coulomb-wedge analysis can be applied to the whole mass of a gravitationally active passive-margin system. This states that the stability of a wedge is defined by 1) the top and bottom slope of the wedge, 2) the internal strength of the wedge, and 3) the resistance to movement of the basal décollement. Active shortening of a wedge occurs where these factors vary in the downdip direction. In passive-margin fold belt settings, the two factors that commonly control wedge stability are the distribution of the décollement horizon and the surface bathymetry. The locus of active shortening in the passive margin wedge, therefore, tends to occur either at the slope toe (the transition from continental rise to continental slope) or at the downdip limit of the décollement lithology. These will be referred to as FATBAST (fold and thrust belt at slope toe) and FATBARDE (fold and thrust belt at regional décollement edge) scenarios. Combination scenarios are possible.

A discussion of likely hydrocarbon systems of orogenic fold belts is found in the literature and will not be repeated here. The systematic differences between orogenic and passive-margin fold belts lead to characteristic differences in the hydrocarbon systems. In a FATBAST scenario, the fold belt develops at the location where the total sediment isopach is at a minimum. Therefore, the maturity level of source rocks also tends to be at a minimum, and such fold belts may therefore have a charge limitation relative to structures in the updip slope. Charge timing is also generally later in the fold belt than in the updip slope for the same reason. In the FATBARDE scenario, the edge is most commonly formed by the limit of a deep salt layer. In such cases, migration from a subsalt source can occur only through synclinal welds in the deep salt or around the frontal limit of the salt. As a result, the frontal fold is exposed to different charge mechanisms from more updip folds. Migration from supra-salt source kitchens is also possible, but owing to the relatively small amount of shortening seen in FATBARDEs, the source kitchens tend to consist of small isolated synclinal areas. This contrasts with the orogenic setting, in which supra-décollement source kitchens may be more extensiveowing to the presence of multiple thrust repeats.

Part 3: Significance of precursor fold structures

This part focuses on a few key aspects of deepwater salt-cored fold belts, using examples from the outer Kwanza Basin of Angola and several different fold belts of the central US Gulf of Mexico margin, including the Cretaceous/Paleogene age Walker Ridge fold belt, Western Atwater fold belt, and a late Mesozoic age fold belt.

Compressional fold belts in deepwater settings have been a major focus of recent exploration and appraisal activity. However, there is relatively little published literature describing the characteristics of deepwater fold belts in passive margins experiencing large-scale gravity spreading or sliding. These fold belts tend to be different from orogenic fold belts in several respects, and these differences influence the structural style, growth, and ultimately the hydrocarbon systems of the fold belts.

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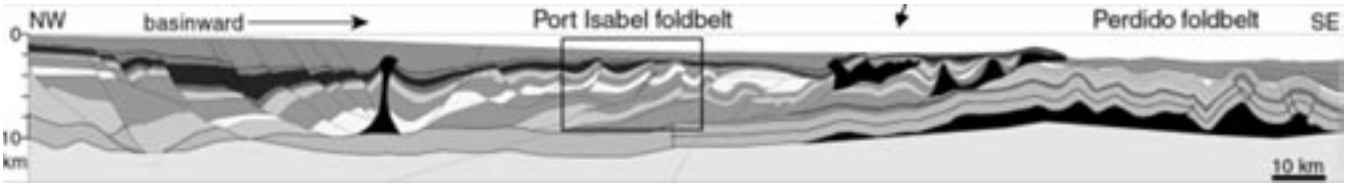
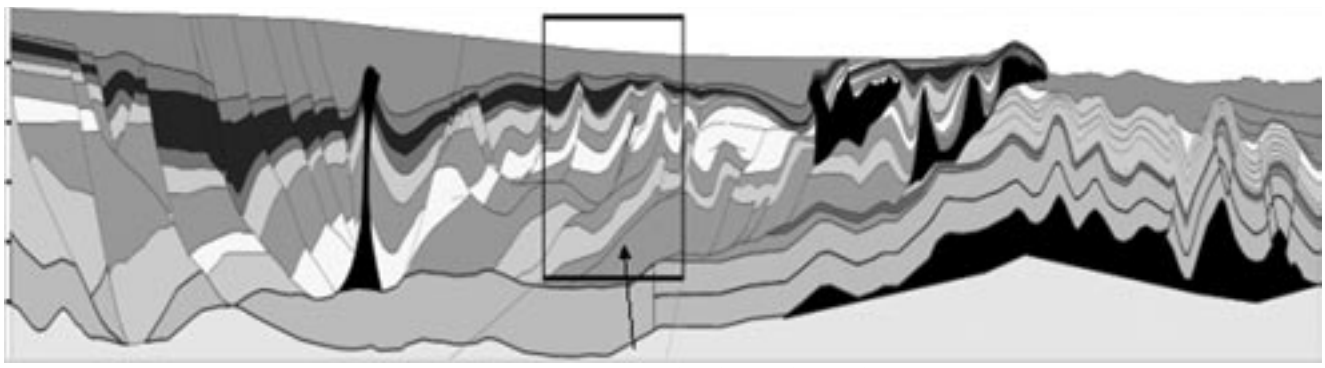
Gulf of Mexico foldbelts

Fold and thrust belt at décollement edge





Fold and thrust belt at slope toe

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Shortening of the sediment cover sequence in passive-margin fold belts commonly occurs very slowly and continuously compared with the shortening in orogenic fold belts. Cover shortening is usually accompanied by continuing deposition on top of the growing fold. As a result, the sediment sequence is much thinner at the onset of folding than it is at a late stage in fold development. Where there is a long history of fold development, early-formed, short-wavelength folds are deactivated and overprinted by later, longer wavelength folds, commonly tripling in wavelength.

Recognition of the precursory structures is important because these control the structural style of the later folds. Reservoir distribution in the lower part of the structure may be controlled by the distribution of the early folds and not by the later, more obvious structures. The early folds may also have a critical influence on hydrocarbon migration paths. ■

Biographical Sketch

Frank Peel was born and raised near Birmingham, England. He earned a BA and MA with honors from the University of Cambridge. He also was awarded an MSc in structural geology from Imperial College, London, and a DPhil (PhD) from the University of Oxford, UK. His doctoral research involved unravelling the structural history of a metamorphic fold and thrust complex in the French Alps.

Frank began his industry career at BP Exploration during 1985. He worked on the subsurface exploration of structurally complex regions in Iraq, Colombia, and the Gulf of Mexico. The assignments included the opportunity to live in the UK, USA, Mexico, and China. In 1996, he moved to BHP Petroleum to take up the role of principal structural geologist, first in Melbourne, Australia, and currently in Houston. Frank has made numerous presentations at international conferences, some of which are published. His interests include anything to do with fresh air, high mountains, and wild open spaces. His work address is 1360 Post Oak Blvd, Houston, TX 77056; phone: 713-961-8322. His e-mail is frank.j.peel@bhpbilliton.com.

Book Review

by **George O. Chandlee,** *Source Environmental Sciences, Inc.*

Cutler, A., 2003, *The Seashell on the Mountaintop: A Story of Science, Sainthood, and the Humble Genius who Discovered a New History of the Earth*, Illustrated. 228 pp. New York: Dutton. $23.95.

The origins of modern principles of historical geology are found in the writings of a Danish scientist named Niels Stensen (1638–1686), or Steno, who is best known in geology for formulating the Theory of Superposition. In *The Seashell on the Mountaintop* Alan Cutler explores the beginnings of the science of stratigraphy and examines the life of Steno. The book addresses the "ancient puzzle that stymied history's greatest minds: How did the fossils of seashells find their way far inland, sometimes high up into the mountains?" (from the book).

Steno's career began as an anatomist and he was widely recognized for his extraordinary skills throughout Europe. He first identified the salivary gland duct now known as "Steno's Duct," and, as a result, was invited to join the Accademia del Cimiento ("Academy of Experiments") in Florence under the patronage of the Medici grand duke, Ferdinand II.

While in Florence, Steno was able to devote time and attention to the paradox of the existence of seashells far inland and in mountains at elevations well above sea level. After fieldwork and a review of existing literature Steno developed the notion that rocks were originally sediments that became lithified later in their history. Though obvious today, his insight was an important contribution to geology, which during Steno's time did not exist as a separate and distinct, legitimate line of scientific inquiry.

In 1668, Steno produced his book *De Solido* that proposed an organic origin for fossil shells. Steno presented a theory of fossilization that proposed that shells found today had not been formed in place nor were not being formed today in subaerial environments. Steno was the first to produce a geologic cross section of Tuscany showing stages in the geological development of that terrane. He used geological illustrations to support his theory of stratigraphic superposition. Steno also assumed that strata were evidence of global events with uniform effects. Although incorrect he was possibly the first to consider a global time scale for the development of strata.

De Solido introduced three fundamental principles central to the development of geology: The Principle of Superposition, the Principle of Original Horizontality, and the Principle of Lateral Continuity.

Steno knew the fate of Galileo, in-house detention, and excommunication, after articulating theories concerning the solar system. Those favoring a biblical interpretation blocked Steno's hypotheses describing the formation, development, and evolution of the earth.

Steno was ordained as a priest in 1675 and two years later became a bishop. He adopted a life of poverty and became wholly committed to Catholicism. His self-imposed life of poverty and ascetism eventually destroyed his health.

After Steno's death in 1686, the debate over the origin of fossils continued. The *De Solido* manuscript circulated throughout Europe with English, German, and Italian scientists debating the concepts and explanations provided in the book. Ultimately Steno's observations and theories proved to be correct but it took several decades for the concepts in *De Solido* to prevail.

Many who followed failed to give proper credit to Steno. In some cases, for example, that of English physician John Woodward, ideas were blatantly stolen from Steno. Woodward assembled the largest collection of seashells in the world and was considered to be the pre-eminent seashell expert. Woodward believed fossils and strata were relics of a single earth-transforming calamity. While this idea was clearly copied from Steno, the controversy surrounding Woodward's interpretation helped keep Steno's ideas alive into the eighteenth century, when they began to take root. Over a century later, geology became a recognized and legitimate course of inquiry and by the first few decades of the 18th century, the biological origin of fossil seashells prevailed.

In 1938, an appeal was made to the Catholic Church to have Steno canonized as a saint. Fifty years later, Steno was recognized and beatified for his contributions to science and to the Church. His life is interesting because he began as an anatomist, typically a very pragmatic occupation, then he became a scientist, addressing highly controversial issues that pitted geological science against religious belief and, finally, he became a Catholic bishop.

The *Seashell on the Mountaintop* will be of interest to geologists because it provides a perspective into the life of Nicolaus Steno known as the "founder of geology" due to his development of laws forming the cornerstone of stratigraphy. The book's appeal, however, extends beyond simply recalling the biography of an important scientist. It also looks at the historical context in which these geologic principles were developed. Therefore, the book will undoubtedly be of interest to non-geologists also because of its historical perspective and because it follows in a very understandable way the development and reasoning for a new explanation and understanding of the earth. ■

Eyes on Earth, from a Houston Perspective

by ***Craig M. Dingler***

HGS President Craig Dingler submitted the following essay to the Houston Chronicle *to help highlight Earth Science Week in Houston. It was published on the* Chronicle*'s Outlook page Monday, October 13, 2003.*

THE stereotypical image of the geologist is that of the lone wanderer plinking rocks, looking for the mother lode or a spot to drill the next Spindletop. That may be a historical representation; nowadays, geoscientists throughout the world perform important work helping to solve some of society's major problems. Using observations and measurements from instruments in space, under water and on the ground, geoscientists constantly evaluate the Earth's present condition. The geologic processes that work on our planet are dynamic, so that the state of the Earth constantly changes. Collecting and assessing geological data helps us predict change so that individuals and society can prepare and respond to the effects.

Geologically, how will Earth's changes affect our future? Earth science research has applications and relevance to our daily lives, especially here in Houston. Most geoscientists work in the business of petroleum exploration to fulfill our energy needs, but many others are involved with sustaining natural resources and mitigating natural disasters. Regionally, these problems include flooding, subsidence, inadequate water supplies and property damage from beach erosion.

Earth science research has applications and relevance to our daily lives, especially here in Houston

Since Tropical Storm Allison, recent advancements in radar technology have enabled the rapid mapping of Houston's flood plains from low-flying aircraft. The maps delineate areas most susceptible to flooding, but also allow geoscientists and others to look in the fourth dimension, time, and see changes in elevation that have taken place on the surface from erosion, development and subsidence. In Houston, where we are so close to sea level, even small differences may have a big effect on flooding.

Subsidence is a geological phenomenon that takes place due to the rapid removal of ground water. It has a direct effect on flooding in the Houston area. Geoscientists monitor changes in elevations using satellite global positioning systems, or GPS, much like the ones found for navigation in automobiles and boats. They can take measurements frequently, cheaply and more accurately than using traditional surveying techniques that were state of the art only a few years ago. These data allow geoscientists and others to see where subsidence is taking place, and at what rate the land is sinking.

Because of subsidence, Houston and other municipalities in southeast Texas use surface water for their citizens' needs. The problem is these water supplies are almost fully allocated between industrial, agricultural and municipal interests. This lack of available water will have a direct effect on urbanization and growth in the Houston area. I can envision a time—soon—when we will have to find political and technological solutions to subsidence in order to tap our prolific Gulf Coast aquifers, the subsurface layers of water-saturated sand. The resource is there, and it is safer from terrorism than our open surface water supplies. However, development must be sustainable and must pay heed to societal and environmental concerns. Geoscientists are already taking geophysical techniques used to find oil and gas deposits and modifying their methods to locate and delineate adequate ground water resources.

Geoscientists monitor climate change and assess its affect on our changing coastlines. About 12,000 years ago, as humans migrated across the Bering land bridge to inhabit the North and South American continents, the Earth was just ending its latest major glacial period. Much water was incorporated in the polar ice caps, and ocean levels were about 400 feet lower than today. Imagine! A trip to the beach would be an extra hour's drive from Galveston!

Where is our present coastline moving? Geoscientists want to know. Most indicators show that between the processes of sedimentation and erosion, erosion is winning out. The Earth's climate is in a constant state of change, and we are still coming out of our last ice age. As icepacks and glaciers continue to melt, the oceans water volume increases and the coastline moves up onto land. The effect may seem glacial in terms of time, also, until we stop to realize the loss in recent history of beach along western Galveston Island and near shore wetlands in south Louisiana.

Funding for monitoring these changes on Earth is largely from federal grants. The president's budget proposals call for cutbacks in federal agencies that provide these funds to geoscientists employed by universities, state agencies and private contractors. Good programs like the state Water Resources Research Institute at Texas A&M University could lose all of their funding. We are all for financial responsibility, but these cutbacks seem shortsighted when considering the lack of water resources and a growing population in Texas and other Western states. Congress has seen fit to restore some funding in its preliminary budgets, much to its credit, but these agencies are an easy mark when trying to balance the budget.

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Houston is still the energy capital of the world. We have the world's largest concentration of geoscientists. They search the globe for oil and gas to supply society's energy needs. That search has led to technical, economic and political advances both at home and abroad, and contributed to the spread of American ideals to every conceivable remote area on our planet. As the Earth's population depletes petroleum resources in the coming decades, the price will escalate beyond what the normal population will consider reasonable. These geoscientists will be on the forefront of technological innovation and creative development of alternative and renewable energy resources.

Look at your planet with open eyes to learn a little about the world around you. Earth stewardship through monitoring and understanding is essential for evaluating its present state and making predictions about how it will change. Only by fully understanding our problems will we be able to conceive practical solutions. Houston's geoscientists are eager to share their knowledge and enthusiasm about the Earth. ■

Eyes on Planet Earth: Monitoring Our Changing World

Earth Science Week 2003 A Huge Success Across Texas

Article and photography by ***Art Berman***

Earth Science Week 2003 officially began in Houston Saturday, October 11, in Pendulum Hall at the Houston Museum of Natural Science. Craig Dingler, Houston Geological Society President, welcomed the hundreds of children and their families who came to celebrate at the Museum. Dingler spoke from a podium in front of the giant Foucault's Pendulum at the entrance to the Weiss Energy Center as he began this year's Family Earth Science Festival.

At the opening ceremony Craig welcomed the excited attendees, spoke about earth science and the meaning of Earth Science Week, and mentioned the many events planned in the Houston area for the coming week. He then mentioned the many sponsoring organizations and their representatives present at the opening. These organizations included the Houston Geological Society, Houston Museum of Natural Science, Houston Gem and Mineral Society, Gulf Coast Section of SEPM, National Association of Black Geologists and Geophysicists, Engineering Science and Technology Council of Houston, Association of Women Geoscientists, Houston chapters of SIPES, SPE TESTA, Rice Student Chapter of AAPG and AAPG Houston House of Delegates. Representatives of these organizations who were present at the opening ceremony with Dingler included Jory Pacht, Robert Johnson, Jim Cartwright, Martha McRae, Jim Allen, Karen Stocco, Deanna Borchers, and Inda Immega.

ESW award recipients (left to right): Darian Coleman, Kevin Robedee (teacher), Errolain Swasey, Craig Dingler (HGS president), Rose Nguyen.

Dingler then introduced the Houston Earth Science Week art and essay contest winners and presented them with their awards. All winners were from Mr. Kevin Robedee's 6th grade science classes (an HISD Middle School. The winners were Errolain Swasey, Darian Coleman, Rose Nguyen, and Gilberto Morales. They were each awarded family four packs to the museum (museum entrance, IMAX, butterfly exhibit, and planetarium for 4 people), a $50 gift certificate to the museum bookstore, a sample of petrified wood and a fossil shark's tooth.

Then the children, their parents, and scoutmasters proceeded to visit the many booths and exhibits staffed by earth science volunteers. Kids got to look into microscopes to see microfossils and then to see these fossils displayed on a screen in real time. There was a workstation booth where the kids were introduced to basic seismic concepts and were able to experiment with interpretations of Gulf Coast geology **Eyes on Planet Earth** *continued on page 25*

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including salt masses. There were booths where geologists and geophysicists explained maps and charts that are used in earth science as well as exhibits where the children could get "hands-on" experience with dinosaur bones and teeth as well as petrified wood. Everything that was seen and touched was from the State of Texas and was explained by working geoscientist volunteers. At the center of the fun was the Passport Center, where volunteers issued "passports" to the exhibits as well as bags of samples and other stimulating earth science souvenirs. In addition to the earth science exhibits the kids enjoyed the many regular museum exhibits and interactive information stations of the Weiss Energy Center.

Craig Dingler commented, "Saturday's program at the HMNS could not be considered anything less than a fabulous success! What a great event! What a crowd! It was very easy to get excited about the science, because the kids were so excited."

Inda Immega said, "As I was leaving, one of the guards stopped me. She said to pass along a bit of feedback from a departing mother with two daughters in tow who had told the guard, 'This was absolutely the best event we have ever attended in any museum. We really enjoyed talking to people who are so excited about science."

Dingler participated as a volunteer at the microfossil exhibit and said later, "It was really fun working at the microfossil table and seeing the kids amazed at the 'very small fossils.' For most, it was their first time looking through a microscope!

"You know that look kids get when they suddenly realize or understand something? Or, as I like to think of it, as their brain suddenly gets a new crease? I can't tell you how many times I saw that look Saturday."

Apparently something was working incredibly well at the Houston Museum of Natural Science on Saturday morning as Earth Science Week began in Houston.

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Of course Saturday's events at the Museum were just the beginning of a fabulous, fun- and learning-filled week for Houston-area children and volunteers. Throughout the week "Classroom Connections" were held all over the metropolitan area as geoscience volunteers spoke with students at area schools on every imaginable topic in earth science. These geoscientists used their own support materials as well as kits and posters made available by the National Earth Science Week organization sponsored by the American Geological Institute.

Following Classroom Connections the weekend of October 18–19 saw a series of "Family -Friendly Fieldtrips." These included a Saturday fossil hunting expedition to Whiskey Bridge in the College Station–Bryan area. Here kids learned about paleontology and were able to find their own fossils to bring home and show to family and friends. On Sunday there was an indoor visit to the Bureau of Economic Geology's Houston Core Facility on West Little York in North Houston. Here children got a rare opportunity to see rocks from deep inside the earth.

This was absolutely the best event we have ever attended in any museum. We really enjoyed talking to people who are so excited about science.

Earth Science Week Houston corporate sponsors included Anadarko, Fugro, Shell, Chevron/Texaco, and BP.

Other events were held across the state by various sponsoring organizations. In Austin there was a career fair for middle school students, an earth science book drive, and teacher workshops. El Paso celebrated Earth Science Week together with its annual "Celebration of Our Mountains" event. In Midland earth science professionals visited K–12 classrooms and featured demonstrations of The Bureau of Economic Geology's 3D visualization laboratory. San Antonio organizers held geophysical experiments as well as rock and mineral displays in area K–12 school classrooms.

Since October 1998, the American Geological Institute has organized Earth Science Week as a national and international event to help the public gain a better understanding and appreciation for the earth sciences and to encourage stewardship of the Earth. This year's Earth Science Week was October 12–18 and celebrated the theme "Eyes on Planet Earth: Monitoring our Changing World." The theme of Earth Science Week in 2003 was selected because monitoring **Eyes on Planet Earth** continued on page 28

Eyes on Planet Earth

continued from page 27

(left to right) Robert Johnson, National Association for Black Geologists and Geophysicists; Karen Stocco, TESTA; Martha McRae, Association for Women Geoscientists; Craig Dingler, HGS President; Deanna Borchers, Rice Student Chapter of AAPG; Inda Immega, AAPG Houston of Delegates; Jory Pacht, Gulf Coast Section of SEPM showing Mayor's Proclamation of Earth Science Week.

the Earth is essential for evaluating its present state and making predictions.

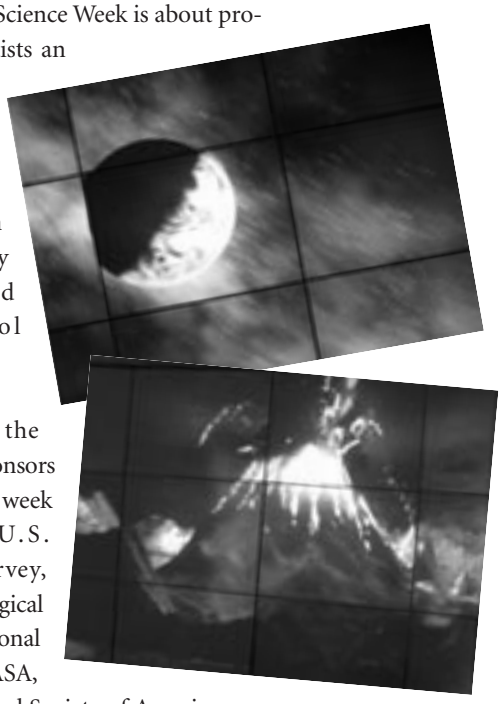
Earth Science Week, observed annually in the United States, Canada, and, increasingly, in other countries, is an opportunity to understand the impact of the earth sciences in our daily lives. The Houston Geological Society is was pleased to join in the celebration for its sixth consecutive year.

Earth Science Week focuses on the Earth and its resources, processes, and hazards. The intent of Earth Science Week is to promote understanding and appreciation of the value of earth science research and its application and relevance to our daily lives.

Specifically this translates into the goals of the Week:

- To engage students in discovering the earth sciences.
- To remind people that earth science is all around us.
- To encourage Earth stewardship through understanding.

Above all Earth Science Week is about providing geoscientists an opportunity to share their knowledge and enthusiasm about the Earth with mostly elementary and middle school children.



In addition to the AGI national sponsors of Earth Science week include the U.S. Geological Survey, many state geological surveys, the National Park Service, NASA, and the Geological Society of America.

Dr. Adena Williams Loston, NASA's Associate Administrator for Education, said, "We seek through our celebration of Earth Science Week another valuable opportunity to inspire and motivate the next generation of explorers to learn more about our home planet."

USGS Director Dr. Charles Groat commented, "The science of the USGS and NASA benefits lives in countless ways. Earth Science Week is a great opportunity to increase public awareness of the diversity of scientific **Eyes on Planet Earth** continued on page 33

HGS Purchases State-of-the-Art Projectors

by ***Art Berman***

The HGS Executive Board authorized purchase of two multi-media projectors at its October meeting. One of the new projectors will be kept at the HGS Office for use principally at Westchase Hilton events, and the other will be downtown mainly for Petroleum Club events. Previously the Society has had to depend on the generosity of sponsoring companies and individuals for its projection needs.

Technology has changed the paradigm of technical presentations. A decade ago most geoscience talks were supported by 35mm slides or overhead displays. Now most talks are given from PowerPoint presentations and projected directly from a laptop computer onto the screen. Initially the cost of these projection systems was very high and required permanent hardware. In recent years portable projection systems have been developed and their cost, though initially high, has come down significantly.

Technology has changed the paradigm of technical presentations. A decade ago most geoscience talks were supported by 35mm slides or overhead displays.

The HGS now owns two Mitsubishi XD300U Colorview Projectors at a cost of about $3000 apiece. Until recently most multi-media projectors employed "flat-panel" technology, essentially the same concept used in viewing a laptop computer screen except projected onto a remote screen via reflected light. The result was good at short screen distance and relatively small image size; with longer throw and greater image size considerable fading and blurring was common.

All projection technology involves an interface or "video card" between the computer and its corresponding monitor. Video cards were designed to view a computer image on a monitor using LCD or "liquid crystal digital" visual elements. Most projection systems attempt to simulate LCD visual affects on a projection screen using reflected light. The simplest video cards are called VGA or "video graphics array" cards and are defined by a resolution range from 320 × 200 to 640 × 480 pixels (a pixel is a "picture cell," literally the smallest, two-dimensional element of a monitor display, similar to a "dot" in graphic terminology) and employ from a few to 256 colors. This results in an image of 307,200 pixels. When projected onto a large monitor or screen the resulting image is limited by this basic element size and tends to look fragmented or "pixelated."

A later modification of video array technology resulted in SVGA or "super" VGA cards that were capable of 800 x 600 pixel resolution (480,000 pixels). Still higher resolution was achieved with the development of TFT or "thin film transistor" arrays that involve resolutions of up to 1024 × 768 pixels (786,434 pixels). TFT is also called an "active matrix" screen in monitor terminology. VGA, SVGA, and TFT are not really distinct array card types but rather the resolution level the video card is capable of resolving. A still higher resolution is called SXGA or "super extended graphics array" that permits 1280 × 1024 pixel resolution (about 1.3 million pixels).

Our new HGS projectors use a new projection technology called DLP or "digital light projection" specifically developed to address remote projection rather than simulation of an LCD display. This technology was developed by Texas Instruments to avoid blurring and fading. DLP is a fundamentally different technology than earlier video cards that takes a monochrome signal from the computer and distributes it to a DMD or "digital micro mirror device," a special board that contains tiny mirrors on a special microchip. Each micro-mirror cluster has a rotating color wheel that divides the monochrome signal into its spectral components as it is projected to the screen. The result is a new level of clarity and color fidelity that eliminates the fading and blurring that resulted from older flat-panel projection systems.

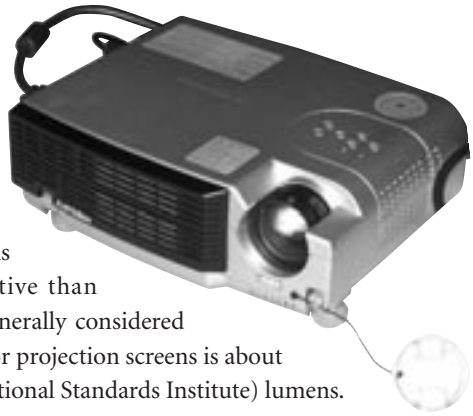


Photo by Art Berman

Image brightness is yet another criterion of image appearance and is measured in lumens. A lumen is the measure of a unit area of illumination. While illumination is somewhat more subjective than resolution a threshold generally considered acceptable illumination for projection screens is about 1000 ANSI (American National Standards Institute) lumens.

The new HGS projectors have SXGA 1280×1024 resolution (1.3 million pixels), 2100 ANSI lumens of brightness, and use DLP projection technology. DLP permits use of 65,000 colors rather than the standard 256. Color balance and fidelity are therefore at the highest level. By any and all measures our organization now owns two of the most advanced image projectors available. Each projector weighs only 6 pounds and is portable in a laptop soft case. Their operation is simple, and they require only 2 minutes to cool after use. The new projectors were first used October 13, 2003, at the October HGS General Dinner Meeting, where Ann Grau and Bob Kidney talked about the Rose and North Shafter fields in California. ■

Global Climate Change—The Conflicting Arguments

by ***Ian G. Bryden*** *and* ***Peter K. J. Robertson***
Centre for Environmental Engineering and Sustainable Energy, The Robert Gordon University, Schoolhill, Aberdeen, AB10 1FR.

The Global Climate Change Committee was formed in 2000 with the following Mission Statement: "To disseminate information which will facilitate balanced dialog on the topic of 'Global Climate Change' in a scientific framework." This article was solicited by Jeff Lund, Global Climate Change Committee Chair and is the latest attempt to fulfill that mission by providing HGS members and other readers of the HGS Bulletin *a current, objective status report on the evidence from an authoritative source. Hopefully, HGS members will be able to use this information to engage and stimulate discussions with the general public.*

Global Climate Change has been a subject of emotive debate over the past two decades. Although there is little disagreement that temperatures in the Northern Hemisphere have been rising rapidly since the 1970s, there are exceptionally polarised opinions over the precise causes of this phenomenon. In this paper we discuss the basic processes involved in the green house effect and critically assess the principal conflicting arguments over what the potential causes of the observed temperature rises may be. In addition potential long term effects of climate change will be considered.

Global climate change is with little doubt the highest profile environmental challenge facing the planet this century.

1. Introduction and Background.

Global climate change is with little doubt the highest profile environmental challenge facing the planet this century. Although few people are informed of problems that water availability will present the globe in the 21st Century, nearly everyone is aware of global warming. The perceived seriousness of the potential global warming problem at an international level resulted in the establishment of the Intergovernmental Panel on Climate Change (IPCC) in 1988. This body was set up to assess anthropogenic causes of climate change and any potential impacts that would result. IPCC has engaged scientists from a range of appropriate disciplines from the international community. To date, IPCC has prepared three assessment reports in 1990, 1995 and most recently in 2001 (1), that have been used to advise the international community through the United Nations Framework Convention on Climate Change. The Kyoto Protocol to the United Nations Framework Convention on Climate Change of 1997 committed developed countries to reducing their emissions of six greenhouse gases by 5.2% of 1990 levels by 2012. Hence global warming has also been one of the main driving forces behind recent government energy and environmental legislation in the European Union and the United Kingdom. Not all countries, however, signed up to this commitment; most significantly the United States refused to ratify the agreement. Australia has refused to ratify the protocol unless the US and developing countries became fully involved. Russia indicated in September 2002 that it would ratify the Kyoto Protocol but has yet to do so. The United States initially indicated that its unwillingness to comply with the Kyoto protocol is due to a lack of convincing evidence that an enhanced global warming effect is taking place. In June 2002, however, the United States Environmental Protection Agency submitted a report to the United Nations which concluded climate change resulted from human activities (2). The report also recognized that global warming would continue and, in addition, total United States greenhouse gas emissions would increase by 43% over the next 20 years. The US and Russia have indicated that their opposition to ratifying the Kyoto agreement results from concerns that the implementation would result in a serious impact on their economies.

There has been much research carried out on what temperature changes have occurred over the past millennium, together with changes in greenhouse gases and other factors that influence global warming. Geological evidence has shown that, over the planet's lifetime, the climate has changed significantly, as have the concentrations of greenhouse gases such as carbon dioxide and methane. This information provides an important background for the comparison of the effects that have been observed in the past 150 years. Many have argued that the current warming that has been observed is due to the Earth moving into a warmer phase, which has not been influenced by the change in greenhouse gas concentrations. Others claim there is a direct causal link between these two factors. This paper will attempt to look at the evidence presented and discuss the various arguments for and against the case of global climate change.

2. The Greenhouse Effect

2.1 Natural and Enhanced Greenhouse Effect

It should be appreciated that there is nothing unnatural about the greenhouse effect. It is a well-understood phenomenon, which acts to regulate the temperature of the earth's surface, oceans, and lower atmosphere. The only controversy is whether or not emissions of gas resulting from human activities, especially industrially related activities, have already or will, in the future, appreciably influence the global climate. It is this human enhanced greenhouse effect which is the cause of so much debate.

Global Climate Change *continued on page 39*

2.2 Physics of the Greenhouse Effect

2.2.1 Atmospheric Characterisation

Prior to describing the nature of the greenhouse phenomenon, it is important to appreciate the meaning of the terms stratosphere and troposphere. The troposphere is the lower atmosphere, which extends from the surface to an altitude of some 11 km. This is the layer of atmosphere in which our weather occurs, which represents an appropriate phenomenological definition of the troposphere. The stratosphere is the upper atmosphere above the troposphere and is characterised by a positive temperature gradient with altitude.

2.2.2 Energy Exchanges

The earth and its atmosphere are exposed to a mean global solar radiation flux equivalent to approximately $342Wm^{-2}$ (3). It is acknowledged now that the annual global flux does change with time and this figure should be taken as representative only. The radiation frequency of this flux ranges from the ultraviolet to near infrared, which represents wavelengths between 0.1 and 4μm. The short wavelength ultraviolet is largely absorbed by ozone in the stratosphere and, to a lesser extent, in the troposphere.

A proportion of the visible and near infrared radiation is reflected back into space by clouds or atmospheric aerosols. A smaller proportion is absorbed. Overall some $77Wm^{-2}$ of the incident flux is directly reflected from clouds and other atmospheric material. Some $30Wm^{-2}$ is reflected directly from the surface and approximately $67Wm^{-2}$ is absorbed directly by the atmosphere. The remaining $163Wm^{-2}$ is absorbed by the surface of the Earth. The land surface, oceans and clouds, which have absorbed the relatively short wavelength solar radiation, subsequentially emit long wavelength infrared radiation, with wavelengths in the range 4 to 50μm. This radiation is prone to absorption in the troposphere and, therefore, contributes to the warming of the lower atmosphere and, consequentially, the surface.

The proportion of the infrared radiation, which is absorbed rather than escaping into space, is affected by the composition of the troposphere. Gases, which make a particular contribution to infrared absorption include, in order of significance: water vapour (H_2O), carbon dioxide (CO_2), ozone (O_3), methane (CH_4) and nitrous oxide (N_2O).

Figure 1 shows a representation of the global energy fluxes between the surface and atmosphere. It is interesting to notice that the surface radiation is a function of the surface temperature. This temperature is a consequence of "historic" warming and should generally exceed the absorbed direct solar flux. Back radiation incident from the atmosphere, as well as loss from convection and evaporation completes the energy balance. It is this back radiation resulting from the emission of infrared radiation by the warmed troposphere itself, which constitutes the green house effect.

In effect, the troposphere acts as an insulating blanket around the Earth, the effectiveness of which will result in an enhancement of the mean temperature of the surface and lower atmosphere. It should be appreciated that the greenhouse effect should not be expected to warm the stratosphere. Indeed, it can be shown that enhanced greenhouse effects should be expected to cool the upper atmosphere. This is **Global Climate Change** continued on page 41

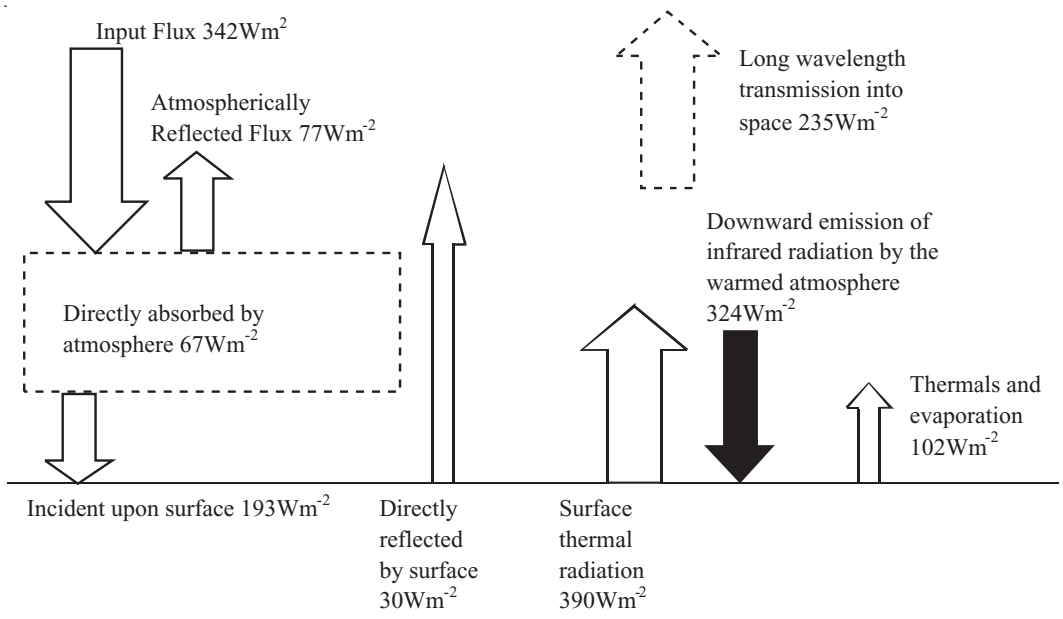


Figure 1. Principal Earth/Atmospheric Energy Exchanges Showing an Overall Balance Between Solar Influx and Long-Wavelength Transmission into Space

because the insulating properties of the lower atmosphere reduces the heating of the stratosphere, which results in a cooler outer atmospheric layer and the emission of less long wavelength infrared radiation to space. There is an analogy here with the effect of insulating a house loft. During snow falls, insulated homes are obvious by the presence of snow lying on the roof, indicating low roof temperatures, while snow will melt rapidly from the roofs of poorly insulated homes.

When considering the influence of the energy balance between the surface and the atmosphere, it is beneficial to consider the overall net radiation flux into the earth atmosphere system because of the very high level of thermal coupling between the surface and the troposphere.

The greenhouse effect maintains the habitability of the Earth. In the absence of the back radiation from the atmosphere, present surface temperatures would induce a substantial imbalance in the input/output fluxes. This would result in rapid surface cooling until a balance was achieved with a considerably reduced surface temperature. This would be substantially below the freezing point of water and insufficient to support life.

As long as the total energy input and output from the earth/atmosphere systems remains in balance, there will be not be any change in the temperature of either the earth surface or atmosphere. There will, of course, be wide short term variations, which are, in effect, manifestations of our short term weather and longer term annual variations.

Modern concerns about the enhanced greenhouse effect relate to changes in the tropospheric absorption of long wavelength infrared radiation emitted by the Earth surface, resulting from changes in atmospheric composition. Water vapour and carbon dioxide occur naturally within the atmosphere and form the primary chemical drivers of the natural greenhouse effect. We now know, however, that the proportion of carbon dioxide, ozone, methane and nitrous oxide have risen substantially as a result of human activity since the industrial revolution.

Radiative Forcing

The term radiative forcing is generally taken as referring to the net change in energy flux into the atmosphere/earth system resulting from a perturbation from a stable state. This makes it a key indicator of changes resulting from modifications in the atmospheric composition, solar radiation or other potential variables. It is a particularly useful concept in assessing the influence of anthropogenic changes in CO_2 levels and other greenhouse gasses.

Somewhat confusingly there are two related representations of radiative forcing. These are:

Instantaneous Radiative Forcing

This refers to the change in net energy flux into the atmosphere/Earth system resulting from a change in state and before any readjustment in temperature within the system.

Adjusted Radiative Forcing

Stratospheric temperatures respond rapidly to any changes in the tropospheric state or the solar energy incidence. An increase in energy absorption in the troposphere, which would result in an instantaneous increase in the overall net energy flux into the earth/atmosphere system, will cause a reduction in stratospheric temperatures. This would then result in a compensating reduction in the overall net flux.

2.3 Factors Influencing the Magnitude of the Greenhouse Effect

The net energy flux into the Earth/Atmosphere system is influenced by a wide range of, frequently interdependent factors, most of which have been discussed in section 3.2. The reflectivity of the atmosphere to the incident short wave radiation is obviously significant, as is the solar intensity. The reflectivity of the surface and clouds is also of direct importance. Much has, for example, been written about the implications of a highly reflective snow covered planet.

The effectiveness of the troposphere as an insulating layer depends upon the concentration of the principal greenhouse active gases and the effectiveness of each of these gases.

Changes in the greenhouse equilibrium of the atmosphere are driven by changes in concentration of greenhouse active gases and the radiative properties of each gas. Similarly, microscopic airborne particles or droplets (aerosols) in the troposphere can reflect solar radiation, which can lead to a cooling in the climate. Changes in aerosol concentrations can also alter quantity of clouds and cloud reflectivity also resulting in cooling.

Volcanic activity can inject sulphur oxides into the stratosphere, which are converted to sulphate aerosols (1). This results in cooling but the effects are usually transitory affecting temperatures for only a few years. Solar activity changes roughly every 11 years (about 0.1% energy change). This may have either a warming or a cooling effect. In addition, over tens to thousands of years, slow variations in the Earth's orbit have led to changes in the seasonal and latitudinal distribution of solar radiation (1).

All of these mechanisms have had a significant influence on climatic variations in the past, for example the glacial and interglacial cycles. When radiative changes occur, the climate responds on a variety of time-scales. The longest of these are due to the large heat capacity of the deep ocean and dynamic adjustment of the ice

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sheets. Consequently the climate response to such changes (either positive or negative) may last thousands of years.

Any changes in the radiative balance of the Earth will alter the hydrological cycles and atmospheric and oceanic circulation. This will affect weather patterns and regional temperatures and precipitation. Any human-induced climate changes will be embedded in a background of natural climatic variations that occur on a range of time- and space-scales. The question to be addressed is, are the observed climate change affects a result of human or natural phenomena?

3. Data on Temperature Rise and Atmospheric Gas Content

Since the late 19th century the global surface temperature has increased by around 0.6C°. The 1990s has been the warmest decade, while 2002 was the warmest year since 1861, when instrumental records began. Global warming has been most pronounced in the Northern Hemisphere, where the temperature increase has accelerated to around 0.1°C per decade since the 1950s. This temperature rise has accelerated further since 1979 with a rise of 0.15 °C per decade recorded (1). While these temperature rises have been observed in the lower troposphere, there have been no significant temperature increases in the upper troposphere while significant cooling has been observed in the stratosphere. As discussed in an earlier section, this apparent paradox is a predicted feature of an enhanced greenhouse effect!

It is difficult to draw any significant conclusions on climate change using data recorded over a relatively short (150 year) period. It is therefore important to consider temperature changes prior to those observed since records began in 1861. Over the past twenty years there has been a significant improvement in the knowledge of temperature trends during the previous millennium. Data have been obtained from a number of sources, primarily gas bubbles trapped in ice cores taken in Greenland and Antarctica (3). From this research it is apparent that temperature in the Northern Hemisphere has been far from stable over this period. In particular the "Medieval Warm Period" occurred between the 11th to 14th centuries. This was followed by what is often referred to as the "Little Ice Age" between the 15th and 19th centuries. Consequently some researchers have argued that the temperature increase observed over the past 150 years is a recovery from the cool period between the 15th and 19th Centuries. What appears to be significant is the fact the rate of temperature increase over this period is significantly greater than any other temperature fluctuations observed over the past millennium.

There would, therefore, appear to be little argument that temperatures have increased since 1861 and the rate of increase is accelerating. The cause of this effect is, however, the subject of this great debate. One of the main arguments presented is the increase in greenhouse gasses over the same period as the temperature rise. The concentrations of greenhouse gases over the millennium were generally stable. Since the 1850s there has been a clear increase in the atmospheric concentration of each greenhouse gas.

The concentration of carbon dioxide (CO_2) has increased from 280 parts per million (ppm) in 1750 to 370 ppm in 2002 (1). This increase in concentration of CO_2 together with the associated radiative forcing contributes around 60% of the effect of all the greenhouse gases. There has also been a significant acceleration in the rate of increase in CO_2 concentration during the 20th century. The increase of CO_2 has resulted from a combination of factors including combustion of carbonous materials such as fossil fuels (1,3). Different fuels output different quantities of CO_2 when combusted, ranging from coal which releases up to 26.6 kg of carbon per GJ of energy released, while natural gas releases around 14 kg of carbon per GJ of energy (3). Deforestation is also associated with the increase in CO_2. This is through a combination of CO_2 released from decaying material, combustion of the forests and the reduction in foliage available to absorb CO_2 through photosynthesis (3).

The atmospheric concentration of methane has also significantly increased over the same period from 700ppb in 1750 to a current level of 1745 ppb (1). This is still increasing; however the rate has started to decrease. Methane is approximately equally produced from natural and anthropogenic sources. The anthropogenic sources include combustion of fossil fuels, biomass combustion, landfill and sewage plant operations and totals up to 615 Tg per year. Farm animals also generate a not insignificant quantity of methane (up to 100 Tg per year) (3) but good taste prevents us from discussing the production mechanism! The direct radiative forcing from methane has been estimated to be in the order of 20% of the total for greenhouse gasses at 0.48 Wm^{-2}.

Nitrous oxide also results from both natural and anthropogenic sources, in particular nitrogenous fertilisers. Over the period 1980 to 1998 the atmospheric concentration of nitrous oxide has increased at around 0.25% per year and the concentration in the atmosphere in 1998 is 16% greater than in 1750 (314 and 270 ppb, respectively) (1). The radiative forcing of nitrous oxide is around 0.15 Wm^{-2} or 6% of the total greenhouse gas radiative forcing.

Halocarbons present a particular problem, as some are extremely effective infra red absorbers (up to 22,000 times that of CO_2) and are exceptionally Global Climate Change continued on page 45

persistent, remaining in the atmosphere for 100 years or, in the case of perfluoromethane, 50,000 years (1). Action taken by many governments as a result of the Montreal Protocol has resulted in a decrease in many of these compounds, in particular chlorofluorocarbons, which have been associated with the depletion of the stratospheric ozone layer. The rate of increase of other compounds has started to decrease. These compounds are almost entirely produced from anthropogenic sources such as refrigerants or cleaning and degreasing fluids. The total radiative forcing of halocarbons has been estimated to be of the order of 0.34 Wm^{-2}, (14% of the radiative forcing from all greenhouse gases) (1).

Ozone is generated indirectly in the atmosphere via photochemical processes involving oxygen with high energy ultraviolet (UV) light. The residence time of ozone in the atmosphere is relatively short (weeks to months). In the past twenty years the reduction of the ozone layer in the stratosphere has resulted in a cooling of the surface troposphere. This cooling is believed to have offset the warming effects of the other greenhouse gases. In addition the thinning in the ozone layer also allows the transmission of more UV light. This UV light can promote the photochemical degradation of species such as methane and halocarbons in the atmosphere (1).

Over the longer term, geological data have indicated that the current concentrations of these gases, with the exception of ozone, are currently at their highest level for 420,000 years (1).

Data on changes in water vapour are more difficult to obtain. The water vapour in the lower atmosphere will increase with increasing temperature. This in-turn will have an additional warming effect (4). Water vapour can also condense forming clouds. Clouds may have either a warming or a cooling effect. The cloud cover will keep heat within the lower atmosphere through reflection. Conversely it can also prevent heat from reaching the surface of the planet by blocking solar radiation. Data on water vapour changes is available only for the past three decades. These data indicates an increase in water vapour of between 3 and 10% per decade (3).

The atmospheric concentrations of aerosols in the troposphere have also increased due to particulate emissions from anthropogenic sources such as combustion, energy generation or vehicle emissions. These aerosols are composed of a combination of particles including sulphate, fossil fuel organic carbon and fossil fuel black carbon, which may have either a warming or cooling effect. The physical/chemical characteristics and spatial distribution of the aerosols will influence the magnitude of the radiative forcing, which will have an overall cooling effect (1).

4. The Arguments Whether or Not Anthropogenic Sources influence the Greenhouse Effect

The consensus among many scientists and policy makers is that the observed temperature rise over the past 150 years is a direct consequence of the rise in greenhouse gas concentration (1,4) There have been other groups that have forcefully expressed their doubts that the enhanced warming is due to these factors and is a natural phenomenon.

A common argument used by sceptics is that the planet is a dynamic environment and that changes in temperature over the past 150 years are insignificant when observed over the lifetime of the planet. Although it is agreed that the planet has gone through phases of significant temperature change, what is significant about the recent observed warming is the rate of temperature increase, rather than just the magnitude of increase.

A criticism that has been used against the argument for human influence in climate change is that the temperature change has coincided with the increase in greenhouse gas emission. It has been argued that there should be a lag between the build up in greenhouse gas concentrations in the atmosphere and the increase in temperature. In addition, it is also claimed that the greenhouse gas emissions have been too small to account for the observed temperature changes. If this argument holds any truth, then the long term consequences could be even more worrying for us, as it implies that we have not yet experienced the full impact of changes in the atmosphere!

The way in which, and the locations where, the data have been gathered have also been criticised. Regrettably, research into global phenomena will always depend on a variety of measurements, many of them indirect by nature. There should now, as a matter of urgency, be an international effort to improve the quality of data measurement. The United States and other developed nations would appear to be the best prepared to fund and implement such a programme. In particular as the energy industry has much of the infrastructure to resource such a programme, this sector should take a leading role in these activities.

Another argument against global warming is the influence of solar activity. It has been claimed that the warming is due to increased solar activity and some models have been presented that match the increase in warming with higher solar activity and this has resulted in a 0.3 °C increase in temperature observed over the past 20 years.

Frohlich and Lean (5) compared the composite total solar irradiance (TSI) record

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measured by space craft over a 23 year period with an empirical model of TSI variations. The authors discussed how, using these records to extrapolate back to around 1650, it could be demonstrated that solar change has resulted in up to a 0.4 °C increase in temperature. This would suggest that the observed warming is a result of changes in solar activity and post industrial greenhouse gas emission would have little effect on climate change.

The way in which much of the solar variability data was gathered has recently been criticised. It has been claimed the drifts in instrument sensitivities were not accounted for when making measurements (6).

5. Potential Long-Term Effects of Climate Change

There are a number of potential effects which may have either a negative or in some cases a positive impact. The predicted effects will vary over different latitudes in the planet and include changes in sea level, precipitation, water availability and food production. It is important to consider that whether or not the temperature increase results from human influence, these changes may result from the warmer climate that we are experiencing. The argument over the magnitude of the anthropogenic influence on climate change is therefore of little consequence when considering such effects.

The major potential consequence is a rise in sea level. This has been predicted to result from a combination of melting glaciers and polar ice caps or more significantly thermal expansion of the sea due to the increased surface temperature. A reduction of Arctic sea ice has been observed in the spring and summer of between 10 and 15%. The annual loss of ice from glaciers in the central Asian state of Kazakhstan has been reported to be nearly two cubic kilometres in the latter part of 20th Century (7). In contrast, no reduction of Antarctic ice has been observed with even a slight increase being reported (1). The rate of global mean sea level increase was reported to be in the range 1.0 to 2.0 mm per annum during the 20th century (1). It should be noted that the increase in sea level is unlikely to be affected by the melting of the Artic ice, since this is floating no net water level rise should result. The rise in sea level may have a number of effects including increase coastal erosion, and flooding of low lying lands and islands. An example would be Bangladesh, where flooding could result in loss of 10% of land. (1,8). In particular, the rice fields could be reduced by 50% affecting the livelihood of over 5 million people (9). Coastal aquifers may be damaged by saline intrusion as salty groundwater rises. The movement of the salt-front up estuaries would affect freshwater pumping plants upriver.

Ironically, large scale climatic change could severely modify the nature of the North Atlantic drift pattern and plunge North West Europe into an extended period of very severe winters similar to those of the equivalent latitudes on the Canadian east coast. The impact of such changes on the heavily populated European Atlantic margin could be regrettable.

An increase in rainfall has also been predicted for several regions in the Northern Hemisphere. As the temperature increases there is an increase in evaporation and the warmer air can hold more moisture. This subsequently leads to an increase in rainfall. The hydrological cycle is however exceptionally complex and how the change in rainfall will affect surface water and vegetation is difficult to predict. During the 20th century an increase in annual land rainfall of around 0.5 to 1% per decade was observed in the middle and high latitudes of the Northern Hemisphere (1).

As a consequence of the changes in precipitation, water availability will be another consequence of climate change. Some models predict that rainfall will be significantly more torrential, leading to more flooding. This may in turn result in less water being taken up by soil which will alter ground and surface water supplies. In addition, while some areas will experience more rainfall others will have less. While there will be increased availability in high latitudes of the Northern Hemisphere, decreases are predicted for southern Europe, the Middle East, central Asia and Africa (1,9). Arid and semi-arid areas, deltas, low-lying coasts, and small islands will be particularly vulnerable. The water availability problems will particularly affect developing countries and add to the demand for water resulting from economic development and population growth. Many of these areas already experience serious difficulties from water shortage so the problems are likely to be exacerbated. The Middle East, for example, currently has 1% of the Worlds available water and 5% of the population (10). The problems with water availability in this region may potentially lead to further political instability in this already very unsettled region of the globe. It has even been suggested that areas such as Ireland may experience water shortages as a result of climate change (10). The Irish Environmental Protection Agency has warned that, although rainfall in the winter may increase by 10%, there may be a summer rainfall reduction of up to 40% in the south and east coast of Ireland (11).

The increase in CO_2 concentration coupled with the warmer climate may increase cereal crop yields in the middle and high latitudes of the Northern Hemisphere (4). Unfortunately in the Middle East, India and Africa crop yields would be reduced. Reduced rainfall and water runoff would cause a reduction in soil moisture which will affect crop growth. The change in water temperature resulting from climate change will affect the ecology of water systems. Nutrient and dissolved oxygen levels may also be affected. A recent report in Nature (12) has also reported a potential link between climate warming and fish harvests in Africa. The sardine harvest Global Climate Change continued on page 49

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in Lake Tanganyika has reduced by around 50% since the 1970s and has been associated with an increase in air temperatures over the lake of 1.5 °C (12). This has resulted in a reduction in the algal growth which is the main source of food for the fish.

6. Conclusions

There is clearly no overall consensus on the human contribution to the greenhouse effect and the relationship between the observed temperature increases over the past century. Much of the disagreements concern the nature of data and the way in which they are gathered and presented by both sides in the debate. A criticism that could be levelled at both sides is that interested parties have a specific bias based on their own viewpoint and, consequentially, interpret data to support their view and criticise data which does not support their position. Environmentalists frequently attempt to use the greenhouse argument to justify the creation of a non-industrial society. Irrespective of whether or not there is an irrefutable link between greenhouse gas emission and global temperature rise, technology has to be the solution to problems created by global climate change. Equally it is not safe to take the attitude that there is no link between atmospheric emissions and climate change.

The evidence that is available at present does suggest a link between anthropogenic gas emission and global warming. What is not known yet is the magnitude of this relationship. It is clear that the potential association between gas emission and climate change can not just be ignored and underlying physics suggests there is a connection. It is vital that society takes steps to implement a comprehensive monitoring programme to establish the extent of the link and any potential future impacts. This will aid governments to undertake any associated planning that might be necessary to accommodate any climatic reaction and subsequent global consequences. This may have a two fold impact to industry. New opportunities for development of technology to address the impacts of climate change may be required, opening up a whole new prospective market. Unfortunately there may be additional financial burdens in terms of more stringent emission control requirements and higher insurance costs. Irrespective of whether there is a proven detrimental consequence of artificial greenhouse gas emissions the energy production industries are not responsible for this. It is the consumers who should be considered culpable; the energy industries only meet their demands. ■

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HGS Financial Summary for 2002—2003

by ***Carol Lucas*** *and* ***Parrish Erwin***

Your Houston Geological Society ended the fiscal year with much strengthened finances. Net income was very high because of income received as a result of the 2002 AAPG Annual Meeting. Income booked to the 2002–2003 fiscal year was about $776,000 and expenses were about $579,000 for a net income of approximately $196,000.

The society's big-ticket items remain the HGS *Bulletin*, office expenses, meetings, and entertainment events. Advertising income more than covered the cost of the *Bulletin* this year. *Bulletin* expenses were slightly lower than the previous year.

Income and expenses from monthly lunch and dinner meetings were much higher mostly because of increased attendance. Total attendance at lunch and dinner meetings was more than 3500. The international group had the highest attendance again.

Entertainment events were very successful this year and showed a strong profit, particularly from the Golf Tournament and the Shrimp Peel.

Office expenses were higher mostly because of increased payroll costs associated with a bigger workload and the website upgrade. Office expenses are offset by dues income and from sharing expenses with the Geophysical Society of Houston (GSH). HGS and GSH also share income and expenses from the Membership Directory, the Shrimp Peel, and the Fishing Tournament.

The HGS share of the net income from the 2002 AAPG Annual Meeting was very high owing to the record attendance. HGS received a portion of the income because of the substantial volunteer participation by HGS members as well as the number of continuing education courses and field trips organized by HGS.

The majority of income received from the AAPG meeting was directed to the HGS investment account. The much larger size of the investment account warranted a review of the HGS portfolio and a shift to a more diversified portfolio is under way. The remaining portion of the AAPG income was set aside to fund enhancements to the website, buy needed equipment, and fund other activities such as a new exhibit booth. Some of these expenditures were booked in the 2002–2003 fiscal year, but most of the expenses will be incurred in the 2003–2004 fiscal year. ■

HGS Preliminary 2002—2003* Profit & Loss

	INCOME	EXPENSE	PROFIT/LOSS
AAPG	209966	769	209197
APPEX	5000	0	5000
Ballot	0	1371	-1371
Bank	1500	1057	443
Board	0	1249	-1249
Bulletin	150458	145346	5112
Computer	4324	7095	-2771
Cont Ed	10190	4754	5436
Directory	14979	22697	-7718
Donation	12440	20586	-8146
Dues	79109	3171	75938
Earth Science Week	3000	4733	-1733
Entertainment Events	97856	88989	8867
Exhibits	0	5170	-5170
Field Trips	425	0	425
Finance	0	142	-142
GSH	43703	0	43703
Interest/Capital Gains	14707	0	14707
Meetings	119909	114026	5883
Membership	0	100	-100
Miscellaneous	250	0	250
New Publications	600	0	600
Office	3660	148010	-144350
Other	15	0	15
Presidential/Awards	0	8249	-8249
Publication Sales	3537	1786	1751
Totals	**775628**	**579300**	**196328**

ENTERTAIN EVENTS	Income	Expense	Profit/Loss
Fishing Tournament	0	0	0
Golf Tournament	60486	53594	6892
Guest Night	19620	19945	-325
Shrimp Peel	14320	11508	2812
Skeet	240	1000	-760
Tennis	3190	2721	469
Other	0	221	-221
Totals	**97856**	**88989**	**8867**

View as of October 10, 2003. Numbers are not final; some amounts have not been reconciled yet. Some activities near the start or near the end of the fiscal year may have financial results that are partially booked in the preceding or following fiscal year, respectively.
Some minor accounts are not shown.
** Fiscal year from July 1, 2002 to June 30, 2003.*

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additional edits where needed. The compiled edits are then sent back to Lisa, who incorporates the edits and develops a second draft. Many times the edits have resulted in additional pages. The printing process requires that the total number of pages in the *Bulletin* is a multiple of four. When the pages are not divisible by four we put our heads together and find interesting pieces of information that will fill the additional space.

The final *Bulletin* layout is delivered to Prime Source with a deadline of the first week of the preceding month of publication. The printing process takes 10 working days and includes binding. Pages are printed on 17- by 11-inch sheets, both front and back (this is where the four-page multiple originates). The sheets are collated and bound into the *Bulletin*. Once all 4,000+ copies are printed and bound, Prime Source submits them to the mail house. Your name is inkjetted on the *Bulletin* at the mail house. The mail house has five days to address and submit copies sorted for delivery to the US Post Office.

My thanks go to everyone involved for making this effort fun and rewarding. As a society we have an outstanding membership and a very talented and enthusiastic *Bulletin* staff. Without these people I would be lost. So thanks, everyone. I also want to wish each and every one of you a very happy holiday season and remind you that this is your *Bulletin*, so please let me hear from you—good or bad, it's all good! Happy Holidays. ■

A Missing Credit – **Allyson K. Anderson**, ExxonMobil Exploration Company, submitted last month's article entitled "Association for Women Geoscientists—Re-establish a Local Chapter."

HGA *and* GeoWives **News**

by ***Anne Rogers,*** *Third Vice President*

This year HGA will be enjoying its holiday program at the Great Caruso Dinner theatre on December 4. We can be sure of an amusing and festive musical entertainment and lunch. The doors will open at 11 a.m. Tickets are $27 for members of HGA and HGS and $30 for other guests. Spouses and friends are welcome. Suzanne Howell is the Chairperson for this event, 713-467-2140.

With the dark days of winter upon us, the New Year would be a good time to join one of our two bridge groups which meet regularly. The Petroleum Club Bridge Group is run by Daisy Wood and meets on the 3rd Wednesday monthly, 10 a.m.– 2:30 p.m. For reservations call Daisy at 713-977-7319. The "Cinco Mas" Group plays on the second Thursday of the month at the Junior League. Call Audrey Tompkins at 713-686-0005 for reservations.

Save the Day: Bridge/Game Day on Monday, February 16, 2004

As a member of HGA you are invited to join

GeoWives

2003–2004 dues are $7.50

make check payable to *GeoWives* and mail to:

Dene Grove
12715 Pebblebrook
Houston, Texas 77024

Please provide the following

Name: _____

Sreet Address: _____

_____

City/State/Zip: _____

_____

Telephone: _____

email: _____

GeoWives

We are celebrating the holidays in two ways this year. Monday, December 8, following a 10.30 a.m. Brunch at Memorial Drive Presbyterian Church, 11612 Memorial Drive, we will car pool to Tremont Retirement Community to sing carols to the residents at noon. Betty Frost will be accompanying us on the piano. Guests who enjoy singing carols will be very welcome!

Monday, December 15 at 7 p.m., you are invited to enjoy an evening at Daisy Woods'. Call Daisy at 713 977-7319 for more details.

The Boards of HGA and GeoWives wish you all happy and safe holidays.

You are invited to become a member of

Houston Geological Auxiliary

2003–2004 dues are $20.00

make check payable to *Houston Geological Auxiliary* and mail to:

Audrey Tomkins • 3007 Stalley • Houston, Texas 77092

HGA YEARBOOK INFORMATION

Last Name	First Name	Name Tag

Spouse Name	Name Tag	HGS Members Company

Home Phone	Business Phone	Business Fax
( )	( )	( )

Street Address	City	Zip

Birthday, Month, Day ONLY	Email Address	Home Fax
		( )