June, 1992

BULLETIN

HOUSTON GEOLOGICAL SOCIETY

lume 34

mber 10

HGS OFFICER ELECTION RESULTS, Page 3
HGS JOBS HOTLINE! Page 45

IN THIS ISSUE...

— Nightmare Travels on a Mule .... Page 16
— Petroleum Storage Tank Remediation Fund .... Page 26
— 3-D Seismic Technology Pays Off .... Page 36
— A Creationist Blunder Table .... Page 39
— The Case for Early Generation and Accumulation of Oil .... Page 57

PLUS MORE!

(For June Events, see Calendar and Geo-events section, page 43)

The HGS Field Trip Committee presents:

Sequence Stratigraphy and Depositional Environments of the Paleocene and Eocene of the Lower Brazos River Valley

Saturday, September 26

Thomas E. Yancey (Texas A&M) and Peter Vail (Rice University)

Covering the updip Paleocene and Eocene section exposed in outcrops along the Brazos River Valley. Alternating marine and non-marine were deposited in a variety of shelf, near shore, and coastal plain environments. Transgressive and highstand intervals will be examined in outcrop. Comparisons will be made to sequence stratigraphies established for lower Tertiary sections in other parts of the Gulf Coast region.

Departure will be at 7:30 AM, returning approx. 8:00 PM. Transportation, BBQ lunch, refreshments and guidebook are included.

For details and reservations, call 341-1800 ext. 33.

HOUSTON GEOLOGICAL SOCIETY

7171 Harwin, Suite 314 Houston, Texas 77036-2190
(713) 785-6402

The *BULLETIN* HOUSTON GEOLOGICAL SOCIETY (ISSN 0018-6686) is published monthly except July and August by the Houston Geological Society, 7171 Harwin, Suite 314, Houston, Texas 77036. Subscription to the *BULLETIN* HOUSTON GEOLOGICAL SOCIETY is included in membership dues ($18.00 annually). Subscription price for non-members within the contiguous U.S. is $25.00 per year and $46.00 per year for those outside the contiguous U.S. Single copy price is $3.00. Second-Class Postage paid at Houston, Texas.

POSTMASTER: Send address changes to *BULLETIN* HOUSTON GEOLOGICAL SOCIETY, 7171 Harwin, Suite 314, Houston, TX 77036-2190.

BULLETIN
HOUSTON GEOLOGICAL SOCIETY

Vol. 34, No. 10 June, 1992

Manuscripts, inquiries, or suggestions should be directed to Editor, c/o HGS Bulletin, 7171 Harwin, Suite 314, Houston, TX 77036. Deadline for copy is six weeks prior to publication. All copy must be typewritten and double-spaced on standard white paper. Line drawings and other illustrations must be photo-ready. If prepared on a word processor, please send a copy of the computer disc, preferably in either Pagemaker or Ventura format.

Photographs submitted for publication are welcome, but cannot be returned.

CONTENTS

DEPARTMENTS

Contents Continued

President's Comments 5

Editor's Comments 8

Commentaries 9

Society Meetings

HGS Guest Night, "Antarctica" 10

"Depositional Cycles, Composite Sea Level Changes, Cycle Stacking Patterns, and the Hierarchy of Stratigraphic Forcing: Example from the Middle Triassic Latemar of the Dolomites (Northern Italy)", *Robert K. Goldhammer* 13

"Groundwater Treatment Using Advanced Membrane Technology", *Ed Shaw* 24

International Explorationists 12

Geotales from Far Away — "Nightmare Travels on a Mule or a Geological Field Trip of the Venezuelan Andes", *Hugh J. Mitchell-Tapping* 16

PRICE SCHEDULE— JUNE MEETINGS

(Non-members: add $2.00 to the meal price)
See **Meetings** abstracts for times

HGS International Explorationists
Dinner Meeting, June 15
Post Oak Doubletree Inn $21.00

RESERVATIONS POLICY

Reservations are made by calling the HGS office (785-6402). At the meeting, names are checked against the reservation list. Those with reservations will be sold tickets immediately. **Those without reservations will be asked to wait for available seats, and a $2 surcharge will be added to the price of the ticket. All who do not honor their reservations will be billed for the price of the meal.** If a reservation cannot be kept, please cancel or send someone in your place.

The Houston Geological Society office is located at **7171 Harwin, Suite 314, Houston, Texas 77036.** The telephone number is **(713) 785-6402; FAX (713) 785-0553.**

Contents Continued

Environmental/Engineering Geologists 24

Environmental Update —
"Petroleum Storage Tank Remediation Fund", *Ramon E. Dasch* 26

Environmental Notes, *RCRA/CERCLA Newsletter* 28

Opinion —
"Environmental Versus Exploration and Production Spending",
William Feathergail Wilson 32

Houston Geological Auxiliary 35

Business of Geology —
"3-D Seismic Technology Pays Off for Houston Independent: A Case Study",
Joe B. Foster and Jay E. Valusek 36

Feature — "For Your Information: A Creationist Blunder Table", *Ronnie J. Hastings* 39

Committee News 44

Honorary Life Award 50

Distinguished Service Awards 52

President's Awards 54

Earth Science Teacher Award 55

Feature — "The Case For Early Generation and Accumulation of Oil",
H. H. Wilson 57

On The Move 76

Exploration Activity Review, *Bill Eisenhardt* 77

COVER PHOTO:

The Caldwell print (discussed in our Feature article on page 39), whose sectioning shows it to be a carving. Aluminum castings of this print were at one time offered to contributors to Louisiana's Creation Legal Defense Fund or to Carl Baugh's Creation Evidences Museum. (Photo by G. Kuban)

HGS ELECTION RESULTS
1992-1993

President-Elect	**John Biancardi**
Vice-President	**Clint Moore**
Secretary	**Jeannie Fisher Mallick**
Treasurer-Elect	**Ann Martin**
Editor-Elect	**William Feathergail Wilson**
Executive Committeeman	**Jeff Lund**
Executive Committeeman	**Jim Ragsdale**
Amendment to By-Laws	**Approved**

PRESIDENT'S COMMENTS

This month marks the completion of 69 years of existence of the **Houston Geological Society.** It all began in the summer of 1923 when a group of 73 Houston geologists, at the invitation of Donald C. Barton of the Rycade Oil Corporation, began meeting for lunch on the first Friday of each month.

Since that time, the **HGS** has grown to the point where today we are the largest local geologic society in the world with over 5200 members.

GUEST NIGHT

Our **Annual Guest Night** is on June 5th. We will again return to the **Houston Museum of Natural History.** Following a catered dinner and a special awards program, we will have a unique opportunity to view a private showing of **"Antarctica"** in the IMAX theater. After personally reviewing all 40 of the IMAX films during his vacation last year, **Clint Moore** selected **"Antarctica"** for this special showing. **Anadarko,** for whom **Clint** works, is partially underwriting the evening for their **third consecutive year.** Thank you **Clint** and **Anadarko.**

One of the special highlights of the evening will be the presentation of the **HGS Awards** for 1992, which I am pleased to announce as follows:

For his many years of service and ongoing leadership to HGS, **Deet Schumacher** will receive **HGS Honorary Life Membership.**

For their many contributions both to the Society and to other geologic organizations, **Dick Bishop** and **Dan Smith** will receive **HGS Distinguished Service Awards.**

And, several years ago **Chuck Noll** began a tradition of honoring certain individuals who stand out for their efforts and their unique contributions to the Society. This year the **President's Awards** will go to the following: **John Adamick** for his many contributions as Arrangements Chairman and as the current Awards Chairman; **Dave Fontaine** for his contributions as Chair of the Finance Committee, work on the Continuing Education Committee, and his especially insightful ideas and help; **John Gorman** for his tireless work over the years in organizing our premier social event of the year, the Annual Shrimp Peel; **Jim Lantz** for his service, first as a member, and currently as Chair of our very important Continuing Education Committee; and to **Martin Oldani** for his contributions as the former Chair of the Field Trip Committee, Secretary of the HGS Board, and as the current Chair of the Entertainment Committee.

In addition to our regular HGS awards, we will also recognize **Joyce Ramig** from Lanier Middle School for her continuing excellence in earth science teaching.

PROGRAM REVIEW

During the past year we have had many excellent programs and many more are in the planning stage for next fall when **Pat Gordon** takes over as your President.

To review this year: Our Program Chairman and Vice President, **John Biancardi,** put together 19 outstanding and varied technical presentations for the lunch and dinner meetings. **Pinar Yilmaz** and her **International Explorationists Committee** held 9 dinner talks. **Andy Lattu** and his **Midland-Midcontinent Explorationists** held 8 dinner meetings. And the **Environmental and Engineering Committee** under the leadership of **Bob Rieser** held 9 technical dinner meetings, 4 special short courses, and started up the **Career Change Group** to assist those interested in moving into the environmental geology field.

To continue the accolades: the **Field Trip Committee** under **Paul Britt** organized 12 trips in support of the **GCAGS** and **GSA** meetings held in Houston this year. Fall trips are now in the planning stages to Cancun, Mexico (recent carbonates) and to the upper Brazos River (Tertiary Sequence Stratigraphy).

Jim Lantz's hard-working **Continuing Education Committee** organized 11 excellent Short Courses covering a wide variety of subjects.

Martin Oldani's Entertainment Committee helped a lot to lighten up the plight of the petroleum industry with five outstanding social events, the last of which is our **10th Annual Skeet Shoot** which will take place on **June 27th.**

In all this totals to **77 events** which these hard working committees organized!! And to the Chairs of these committees, **please express our thanks and deep appreciation to your entire committee for doing such a Great Job!!**

In addition to our regular events, HGS members were very active in producing three major technical conferences in Houston this year. **Chuck Noll** and **Dan Smith** chaired the **GCAGS Convention** in October. **Denise Butler** and **Michael Nault** worked long and hard organizing the **GCSSEPM Foundation Research Conference** in December. And **Hans Ave' Lallemant** chaired the **Regional GSA Conference** held here in February.

And last but certainly not least I would like to acknowledge the **Houston Geological Auxiliary. Kathryn Bennett** is the President this year and she headed up a group of more than 400 members. Not only did they provide enormous support to their spouses, but they also held five social meetings, and very importantly, donated $1000 of their proceeds to our two Scholarship Foundations. They also provided invaluable support at the GCAGS Convention, to our Shrimp Peel and to our business office. In addition, their smaller subsidiary group, the Geo-Wives Newcomers Club, held nine monthly social meetings to welcome and support transfers to Houston.

OUTREACH PROJECTS

John Chronic's Academic Liaison Committee (20 members) made over 100 presentations to Lower, Middle, and High School earth science classes in the Houston area, presenting geology lectures and career descriptions. They also participated in the judging of 13 science fairs.

And recently they initiated a **new program,** the brainchild of **B. J. Doyle,** which will match up HGS members, one-on-one, with each of the 34 middle and junior high schools in the Houston Independent School District. Once that is fully established, they will expand it to other districts in the area. If you are interested in participating in the program, give **John** or **B. J.** a call. There is room for everybody to participate here!

John Adamick's Awards Committee worked closely with the Texas Earth Science Association to help with the selection of the Annual "Best Earth Science Teacher" Award. They also did a prodigious amount of work preparing nominations for awards for HGS, GCAGS, and AAPG, in addition to securing numerous awards for our speakers, instructors, committee members, and science fairs.

Lillian Roberts and her **Explorer Scout Committee** directed two Explorer Posts in the Houston area. Featured highlights of last year's activities were trips to the Grand Canyon and a trip on an oceanographic research vessel owned by Texas A&M.

Other activities included attendance at the America High Adventure Rally where they prepared a booth outlining their goals and activities, camping trips, speaking to other scout groups about geology, the BSA Bowling All-Nighter, and fund raising activities for their Annual Superactivity Trip and to send two students to the National Exploring Conference in South Carolina.

NEW PUBLICATIONS UPDATE

New publications in progress under the guidance of **Bill Hill's New Publications Committee** consist of a joint project with the New Orleans Geological Society which will catalog *Low Resistivity Pays in the Offshore Gulf of Mexico.* This project is well along in its preparation and **is now available for underwriting. This would be a great project for a company to contribute to.** If interested give him a call.

A second project is a *Seismic Atlas of the Gulf of Mexico Basin.* It is a joint publication with the Geophysical Society of Houston. Letters of intent have been signed with the SEG, who will publish it in 1993.

Two much-talked-about projects are in various stages of completion. They are "Building Stones in the Houston Area" and compilation of a "Surface Fault Map of the Greater Houston Area". What is needed now is for people to step forward and push them through to completion. If you are interested in either of these projects please give **Bill Dupre'** a call.

Continued on page 8

EDITOR'S COMMENTS

This is the last issue of Volume 34 of the HGS *Bulletin* and the end of my editorship. I hope you have been informed, amused, enlightened, and perhaps even irritated. If you have some great ideas for improving the *Bulletin,* or something you'd care to submit, or if you'd just like to work with a great group of people, call Sue van Gelder, 1992-93 *Bulletin* editor, at 466-3348, or Feather Wilson, 1992-93 editor-elect, at 370-9420.

My thanks to all the members of the *Bulletin* Committee who made my job so much easier; to the HGS Board and Committee members who submitted their columns, ads, and reports each month; to all the contributors of articles, letters, commentaries; to the management at Texaco's Exploration and Production Technology Department for its encouragement and the use of its resources; to HGS Secretary, Margaret Blake, for her help and support; and to Martha Maxey and June Gibson at Four Star Printing, who put it all together.

JO ANN LOCKLIN, Editor

President's Comments, cont. from page 6

JOB HOTLINE

A new **Jobs Hotline** has just been installed by **Joe Eubank's** Personnel Placement Committee. It carries a current recording of jobs available at companies who have contacted HGS. Members can call in, update their resumes as appropriate, and then send or fax them to **Joe** for forwarding to the potential employers. (See p. 45 for more details).

BEHIND THE SCENES

Please look over the masthead on page one. There you will see the names of the many unsung but certainly no less important heros and their committees not mentioned earlier in this column. They provide the foundation on which our programs stand. Without their work the Society would not function. Please thank them when you see them, and **if there are any committees on which you would like to serve next year give them a call.** I know they would be more than glad to hear from you.

And then there is my beloved Board of 11 Directors. Please find their names on the masthead as well. They have worked long and hard this year with two major goals in mind: 1) To provide the support needed and wanted by the Committee Chairs, and 2) To make the decisions necessary to ensure the viability and vitality of HGS now and into the future.

Thanks to their hard work and dedication, our member base is stable, our financial condition is very sound, and our committees are operating at higher levels than ever before!!

LASTLY

Since this is my final column as HGS President, I would like to say that it has been an outstanding privilege to serve in this capacity. HGS and its many dedicated volunteers never cease to amaze me, not only for their commitment, but also for their creativeness, dedication, partnership and hard work in spite of the demands of today's workplace. It is truly a model for all volunteer organizations to follow. Congratulations and thank you from the bottom of my heart!!

Have a great summer - See you in September!!

Cy Strong

HGS PREMIER RECOGNITION PROGRAM

Chevron is recognized as a
CHAIRMAN LEVEL
sponsor of the
Houston Geological Society.

COMMENTARIES

GLOBAL WARMING SPAWNS GREENHOUSE GLACIERS

by Deet Schumacher, Pennzoil Co.

No, this isn't a headline from one of those supermarket tabloids. Rather, it is the conclusion of a scientific article recently published in the respectable journal, *Nature* (Jan. 16, 1992).

Popular media has just about convinced most of us that greenhouse gases will cause climates to grow increasingly warm; droughts will become commonplace; deserts will expand; ice caps will melt, and rising sea levels will drown our coastal cities.

Now, along come geologists Gifford Miller and Anne de Vernal to suggest it may not be so. They examined the recent geologic record (130 kyr to present) to obtain an independent assessment of ice-sheet response to climate change. Their study supports arguments that initial ice-sheet growth at the beginning of the last glacial cycle occurred at high northern latitudes (65-85° N) under climate conditions similar to the present. In particular, the conditions most favorable for glacier inception are warm high-latitude oceans, low terrestrial summer temperatures and elevated winter temperatures. Miller and de Vernal find that the geologic data support the idea that greenhouse warming, which is expected to be most pronounced in the Arctic and in winter months, may lead to more snow deposition than melting at high northern latitudes and thus to ice-sheet growth. And with it, undoubtedly, will finally come higher prices for fuel oil and natural gas!

ATLAS OF COMPUTER-GENERATED BIOSTRATIGRAPHIC MAPS CENTRAL GULF OF MEXICO

The Minerals Management Service (MMS) Gulf of Mexico Outer Continental Shelf Region has developed an atlas of biostratigraphic computer-generated contour maps. The data used to develop the maps were extracted from the MMS Gulf of Mexico Region Paleontological Information Computer System.

Only definite biostratigraphic tops occurring in straight holes (less than or equal to 100 feet from true vertical) are used for contour information. All map areas have scales of approximately 1″ = 16000′. The exact scale is noted in the title of each map. Selected major biostratigraphic zones (from Pleistocene through Lower Miocene) are mapped. Only well locations with nonproprietary paleontological information are plotted. All available paleontological information, both proprietary and nonproprietary, is used to generate the contours. The number of data points used within the gridding area is restricted by the coarseness of the grid.

These computer-generated contour maps are offered to the public as a tool for future petroleum exploration and development. They will be updated before each central and western Gulf of Mexico Federal lease sale. Future plans for this atlas series include the use of additional biostratigraphic information and implementation of advanced computer mapping techniques.

Orders should be directed to:

Minerals Management Service
Gulf of Mexico OCS Region
Office of Public Information (MS 5034)
1201 Elmwood Park Boulevard
New Orleans, Louisiana 70123-2394
(Telephone 504/736-2519 or FTS 686-2519)

MEETINGS

HGS 1992 GUEST NIGHT—JUNE 5, 1992 WORTHAM IMAX THEATRE & HOUSTON MUSEUM OF NATURAL SCIENCE

A spectacular IMAX film on the beauty and dangers of ANTARCTICA will be exclusively shown to our 1992 HGS Guest Night participants at the beautiful Wortham IMAX Theatre within the Houston Museum of Natural Science. "ANTARCTICA" carries its audiences to unknown, unimagined places. It takes them on a spectacular helicopter flight through icy chasms and over towering pinnacles, reveals the still and barren Dry Valleys and suits them up for a chilling dive into submerged caverns within the Chaos Glacier. You'll watch in mystical awe as emperor penguins perform a graceful ballet and a mother Weddell seal coaxes her reluctant pup into icy waters for its first swim. In short, you'll be thrilled by the spectacular beauty that is...."**ANTARCTICA**".

The IMAX film and projection system is "the cinema of the future" because the size, scope and quality surpass conventional cinemagraphic methods. The IMAX super 70mm film projection system focuses on a giant screen 80 feet wide and six stories high — ten times the size of a normal movie screen. It is the largest theatre screen within a 500 mile radius of Houston.

For the movie goer, the attraction of the IMAX experience lies in its ability to make the viewer feel he is part of the action on screen. IMAX viewers can almost feel the sensation of weightlessness inside a spacecraft (The Dream is Alive), soar over the majestic Grand Canyon (Grand Canyon), or know the exhilarating experience of rushing 70 miles per hour downhill skiing (To the Limit).

In addition IMAX sound has a six-track wrap-around stereo system featuring four screen channels and two surround channels. The sound of a rocket blast-off becomes extremely realistic as the intense sound tapers off when the rocket soars upward.

(Reprinted with permission from *Museum News*, newsletter of The Houston Museum of Natural Science, and "Antarctica").

NOTE: HGS GUEST NIGHT WILL BE SOLD OUT!

Be sure and arrive at the museum in plenty of time to see the magnificent gem & mineral collection in the Cullen Gallery of Earth Science, as well as the beautiful collection of seashells in the Strake Hall of Malacology. Museum doors will open at 6:00 p.m., so please enter through the Cullen Grand Entry Hall where you and your guest(s) may pick up your preprinted name tags. Cash bars will be available on both levels, as will the Ninfa's Buffets which will start serving dinner after 7:00 p.m. All forty dinner tables will be located in the main museum hall divided equally between both levels. Free parking is provided in spaces around the Museum and along Herman Park Circle, or for a fee ($5.00) one block north of the Museum at Park Plaza Garage. If you cannot attend, substitutions or refunds **may** be possible by calling Margaret at HGS offices (785-6402). Don't be a no show; there will be a waiting list for cancellations so other people can attend if you are unable to do so. Please think of your fellow members and call Margaret if your plans change.

SPECIAL THANKS AGAIN TO ANADARKO PETROLEUM CORPORATION FOR THEIR CONTRIBUTION TO HGS GUEST NIGHT 1992.

GEOTECH '92 EXPANDS TO THE SHERATON DENVER TECH CENTER

GeoTech, the geocomputing conference for earth science professionals, will be held at the Sheraton Denver Tech Convention Center Aug. 21-Sept. 1, 1992. The event experienced such significant growth in 1991 that it had to move to a larger facility for its 1992 conference.

GeoTech, now in its ninth year, is the world's premiere conference devoted exclusively to computers in the earth sciences. This year's technical sessions will include tracks for Petroleum Exploration, Geophysics, Environmental and Groundwater Mining and Minerals, Mapping and GIS and Image Processing. Additionally, two days of workshops are scheduled that will include an intensive "Mapping Software Update." This update will allow delegates to compare and evaluate current software package capabilities and performance.

GeoTech is sponsored by GeoTech Inc., a non-profit corporation formed by geo-professionals to disseminate information on geocomputing. The event is run in cooperation with 12 separate geological societies.

For information on the GeoTech exhibits or conference, please contact Mark Cramer, Expomasters, 7632 E. Costilla Ave., Englewood, Colo. 80112, or phone (303) 771-2000.

INTERNATIONAL EXPLORATIONISTS

Chair's Column

This has been another fun and productive year at the International Group. We sent books and journals donated by numerous International Explorationists members to Dr. Ludwik Krol, Director of Polskie Gornictwo Naftowe I Gazownictwo, Torun, Poland. Exxon Production Research Company funded and took care of the logistics for this shipment. I would like to thank Management of Integrated Basin Analysis Division for enabling us to accomplish this.

We were one of the organizers for the Symposium entitled "Comparison of North American and Eastern European Folded Belts" as part of the Geological Society of America Annual SW Section meeting at Rice University on February 24, 1992. The proceedings of this symposium will be published as a special volume.

There were excellent speakers on diverse topics this year. On September 16, 1991, Gherardo (Gerry) Mercati of AGIP presented "Petroleum Geology of Concession 16/08, in the South China Sea". On October 21, 1991, "Petroleum Geology of Honduras" was given by Richard Mills, consultant. The November 18, 1991 talk was titled "Controlling Factors in the Initiation of the South Atlantic Rift System" by Larry A. Standlee of CONOCO, ER & S. This was followed by another CONOCO talk on January 20, 1992 titled "Early Cretaceous Paleogeography of Gabon/Northeastern Brazil — A Tectono-Stratigraphic Model based on Propagating Rifts? The speaker was C. H. Bradley.

February 25, 1992 was the joint meeting with GSA and HGS International Groups. The talk "Eastern European Mountain Belts: the Highs and Lows" was given by B. Clark Burchfiel and Leigh H. Royden of Massachusetts Institute of Technology. On March 16, 1992, the presentation titled "Comparison of Paleozoic Passive Margin Carbonate Platforms of the Western United States and the Soviet Union" was given by Harry E. Cook, USGS, Menlo Park. This talk was made possible through a grant by Exxon.

On April 20, 1992, Isabelle Moretti of TOTAL(CFP) and IFP presented "The Suez Rift: Structural Pattern and Evolution". On May 18, 1992, the talk "Petroleum Geology of Malta" was by Bill Bishop, consultant. And this month the presentation is titled "Depositional Cycles, Composite Sea Level Changes, Cycle Stacking Patterns, and the Hierarchy of Stratigraphic Forcing: An Example from the Middle Triassic Latemar of the Dolomites, (Northern Italy)" by Robert K. Goldhammer of Exxon Production Research Company.

International Explorationists do not meet in July and August. We will meet again in September, 1992. Wishing you a fun summer.

PINAR O. YILMAZ

EXOTIC ROCKS

We need exotic rocks for our speaker plaques. Please bring a sample of your favorite rock to the next meeting. It will help clean up the boxes you stored in the garage. We acknowledge the donor on the back of the plaque.

INTERNATIONAL EXPLORATIONISTS COMMITTEE MEMBERS 1992-1993

Chairperson & Technical Program:
Pinar Yilmaz, Exxon Prod. Res. Co. 966-6033
Technical Program Assistant:
Gerrit Wind, Amoco 556-3680
Hotel Arrangements:
George Tappan,
Geoservices International 358-4061
A/V Arrangements:
Nat Smith, Consultant 861-0277
Finances & Tickets:
Don Young, AGIP 688-6281
Announcements and company representative contacts:
Thom Tucker, Marathon Oil 629-6600
Directory:
Kumar Bhattacharjee,
Sita Oil Exploration House 999-6957

Please contact your company representative or call HGS for ticket reservations at 785-6402.

COMMITTEE MEETINGS

HGS International Explorationists Committee dinner meetings will be on the **third MONDAY** night of each month at **Post Oak Doubletree Inn in the Galleria** starting with a 5:30 p.m. social hour, 6:30 p.m. dinner and 7:30 p.m. technical presentation.

HGS INTERNATIONAL GROUP DINNER MEETING—JUNE 15, 1992

Post Oak Doubletree Inn
Social hour, 5:30 p.m., Dinner, 6:30 p.m.
Technical Presentation, 7:30 p.m.

ROBERT K. GOLDHAMMER—Biographical Sketch

Bob Goldhammer is originally from Boston, Mass., and received his undergraduate degree from Colgate University in Hamilton, New York in May, 1979. He completed a master's degree at the University of Oklahoma (May, 1982), spent seven months with Exxon, and went on to Johns Hopkins University in Baltimore, Maryland for his doctorate (May, 1987). His Ph.D. thesis focussed on cyclic platform carbonate deposits of the Alpine Triassic. Presently, he is employed by Exxon Production Research Co. residing in the Carbonate Sequence Stratigraphy and Stratigraphic Modeling Group. His work at Exxon has focussed on carbonate cyclostratigraphy and sequence stratigraphy. He has been engaged in a variety of projects, including the Lower Ordovician of West Texas, the Late Proterozoic of the North Slope (Alaska), and the Mesozoic of the Sierra Madre Oriental (northeastern Mexico).

DEPOSITIONAL CYCLES, COMPOSITE SEA LEVEL CHANGES, CYCLE STACKING PATTERNS, AND THE HIERARCHY OF STRATIGRAPHIC FORCING: AN EXAMPLE FROM THE MIDDLE TRIASSIC LATEMAR OF THE DOLOMITES (NORTHERN ITALY)

Carbonate platform deposits record a complex interplay of numerous geodynamic variables, of which eustasy, subsidence, and sediment accumulation are prime factors in determining both the km-scale (depositional sequence-scale) and meter-scale (depositional cycle-scale) stratigraphic packaging. The M. Triassic Latemar platform (740 m thick, 5-6 km wide) provides a seismic-scale outcrop example of an intact carbonate shelf-to-basin transition, ideal for integrating sequence stratigraphy with facies and cyclic stratigraphy. This sub-circular, high-relief buildup records two third-order (1-10 myr) accommodation sequences within the platform interior, the Lower Ladinian Sequence (L1 - 8 myr; 400 m thick) and Upper Ladinian Sequence (L2 - 6 myr; 340 m thick). Sequence 1 developed atop a widespread, low-relief M. Anisian carbonate bank (60 m thick). Underlying subtidal bank cycles thin upward into the basal, subaerial sequence boundary (Type 1) reflecting decreasing third-order accommodation, and above it platform-interior facies of sequence L1 retrograde. This results in superimposition of Ladinian basinal and foreslope facies atop the underlying, horizontal, shallow-water bank along its periphery. The transgressive (TST) and highstand systems tract (HST) of sequence L1 (as well as L2) are marked by long-term, systematic vertical facies changes (subtidal- vs. exposure-dominated facies) and variation in stacking patterns of aggradational high-frequency, 20 kyr cycles (progressive thickening- vs thinning-upward) within the platform interior. The maximum flooding surface (MFS) is a marine hardground surface displaying evidence of very slow sedimentation and is the platform expression of the condensed section. A type 2 SB caps sequence L1, marked by an interval of vertically superimposed thin subaerial tepees; beneath this, high-frequency cycles are thinning-upward, and above they are thickening-upward. Only the transgressive systems tract of sequence L2 is preserved at the Latemar owing to Late Ladinian-Early Carnian volcanism and tectonism, which terminated carbonate platform deposition.

This study examines, in particular, the concept of composite eustasy, that is, superimposed sea level fluctuations with different frequencies (defined as orders) and different amplitudes, and the role it plays in the linkage between meter-scale cyclic stratigraphy and km-scale sequence stratigraphy. The results of this work suggest that there exists a hierarchy of stratigraphic forcing driven by composite eustasy that results in organized stacking patterns (thickness, subfacies character, early diagenetic attributes) of high frequency, typically fourth- and fifth-order, shallow-water carbonate cycles dictated by low frequency, third-order relative sea level effects. This study suggests that systematic vertical changes in stacking patterns of high frequency cycles across a larger depositional sequence is due to systematic and predictable differences in depositional space available during the rising and falling stages of a relative third-order sea level change. This work also suggests that these systematic variations in cycle stacking patterns will exist regardless of the mechanism responsible for generating the high-frequency cycles, be it an autocyclic or allocyclic mechanism. This approach has major implications for the use of high frequency, fourth- and fifth-order cycle characteristics to identify third-order cycles in outcrops and cores of shallow water carbonates, where stratigraphic control may be less than desirable. This would constitute a valuable bridge between cyclic stratigraphy at the meter scale and sequence stratigraphy at the seismic scale.

The Alpine Triassic Ladinian Latemar buildup is a spectacular example, wherein a systematic succession of high-frequency cycle stacking patterns and early diagenetic features exists within an overriding third-order cycle (sequence) reflecting the interplay of short-term, high-frequency (fourth, fifth order) eustasy and long-term, low-frequency (third order) eustasy in accordance with the hierarchy of stratigraphic forcing. Central to the interpretation of these examples is the demonstration that true eustatic rhythms are recorded in the high-frequency cyclicity, as verified by time modeled by computer under conditions of constant lag depth-dependent sedimentation, uniform subsidence, and composite eustasy. An understanding of composite relative sea level changes and the potential for a hierarchy of stratigraphic forcing provides the link between cyclostratigraphy and sequence stratigraphy, and also has important implications regarding the stratigraphy of early diagenesis.

NIGHTMARE TRAVELS ON A MULE

or

A Geological Field Trip of the Venezuelan Andes

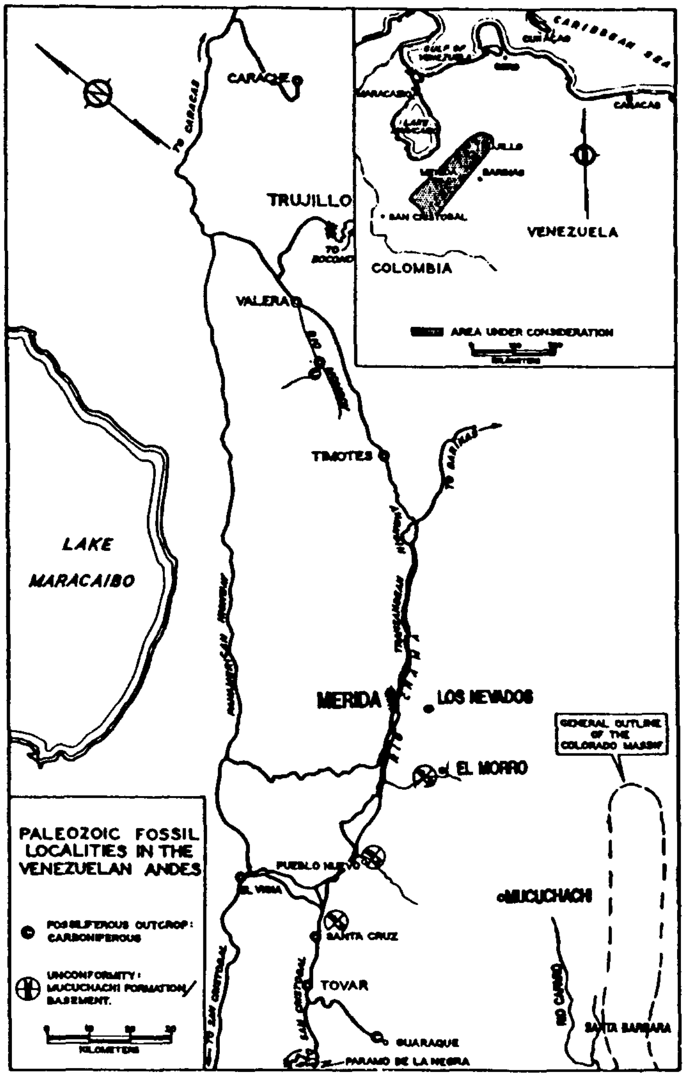
by Hugh J. Mitchell-Tapping, Dallas, Texas

The dark-brown mule was stubborn..........but fortunately surefooted.......as the narrow pathway wound around, up and down the steep-sided mountain. We were now at 4,000 meters with a precipitous drop-off on the right-hand side of the pathway. Fear gripped me at every four-legged step. I had been ready for hours now for him to stumble, and I planned to fall off the mule against the rock face (or was it an outcrop - I really didn't care) on the left side of the path. I had been riding (maybe not the right word - as the mule was the boss and I just another piece of baggage on top) for hours. I was not only saddle sore but my legs were paralyzed: the stirrups were too high for my height. This was it ... a stumble. The mule went down to its knees. We were on a very steep downhill gradient - too steep to walk, perhaps only to climb - sweat rolled down my back as I tried to swing off to the left. No way. I could only lay back on the mule's rear with the saddle digging into my back and the stirrups shining at eye level. My breath had gone. No speech, not even a squeak at this altitude. My only thoughts were "Who was the idiot to suggest this damn field trip?"

This geological field trip through the Venezuelan Andes in western Venezuela was my first on a mule. The field itinerary, to visit described outcrops, called for travel up and down mountains with heights ranging from 2,500 to 4,700m. This Andean trip was part of a field study by Retog Inc., on the Geology and Hydrocarbon Potential of Venezuela, and we had already sweated among the mosquitos of the Orinoco and gotten sunburnt in the Coastal Ranges and the Maturin Basin (but that's another story). At the very outset I felt some internal apprehension when I saw the initial trail marked on the topo sheets. It was formidable and appeared ambitious to reach all the targeted outcrops since the rainy season had already started.

We left Caracas, travel permits and passports at the ready, in a rainstorm which flooded out the carburetor of the van on the main highway (route 5) to Barinas, an oil center lying against the Andean foothills in the Llanos Barinas-Apure basin, our first stop for the night. From Barinas we made our way on the Transandean Highway (route 7) through the Andes, past the Santo Domingo hydroelectric complex for the city at 2,179 m, to the provincial capital of Merida at 1,625 m elevation, our second night's stop. After leaving Merida in four-wheeled-drive vehicles, we crossed a major basement fault onto the Lower Paleozoic Mucuchachi formation. We followed a dirt and rubble road, washed-out in places, to the village of El Morro high in the Andes (2,700 m). This part of the trip was really the beginning of the nightmare. In places, the track was rubble and the jeeps at times were balanced with two wheels

Paleozoic outcrop map of the Merida area of the Venezuelan Andes



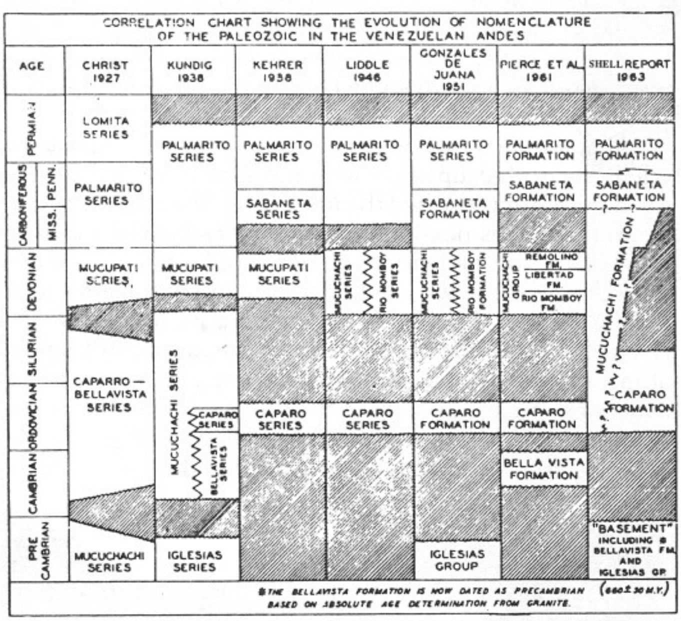
(after Shell & Creole, 1964)

literally inches from a drop of more than a thousand meters. Engine power and the obvious experience of the guides was all that kept fear from developing into panic. Not a word was spoken, lips were parched, and hands were white from gripping the rollerbars........the view was spectacular. Finally, after about three hours (or was it years?), the track widened to nearly 3 meters and we could see the church spire and some roof tops of El Morro perched on a ledge in the distance. We drove along the village stone mainstreet, around the ubiquitous Simon Bolivar square, and on to the lodging house. We all piled out of the two jeeps and staggered around to bring the circulation back to our legs, and laughed to relieve the tension of the ride. Little did we know that this had been a dream trip compared to the upcoming mule nightmare rides of the next few days.

Why, you may ask, were we here?

Well, many researchers over the years have investigated the geology of the Andes, especially oil company geologists. Results of field work have been published by these geologists and interpretations of ages and depositional environments have been proposed. In 1964 Creole and Shell Oil geologists published an article to correct previous 1956 interpretations and age determinations. Fossil collections were previously identified as Devonian; now the same companies wished to correct (perhaps *to rectify and retract* would be more appropriate) the ages of the fossils to Ordovician, Silurian and Permo-Carboniferous, because the original investigations were done by paleontologists inexperienced with Paleozoić faunas. These new findings led to a pronounced revision of the regional stratigraphy and paleontology.

Chart of the different nomenclature from Shell & Creole (1964)

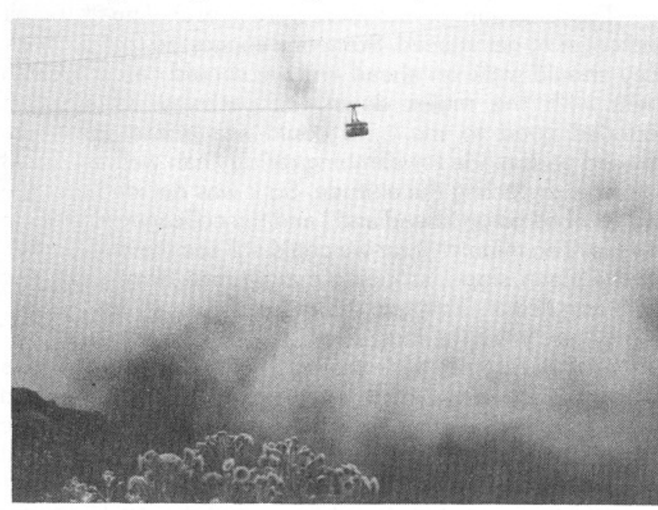


Correlation chart showing evolution of Paleozoic stratigraphic nomenclautre in Merida Andes.

This revision also led to postulation that the Caparo and Mucuchachi formations are time-equivalent: which means that the two formations represent distinct facies within the same Paleozoic basin. If this was so, then I proposed that the position and configuration of the basin could not have changed appreciably throughout the time of the two sedimentary cycles: this concept might have major implications for oil exploration of the Paleozoic Andes concerning both source and reservoir. Most of the field work on known outcrops suggested that the two formations are separate, the Caparo (Ordovician-Silurian) being an older cycle and the Mucuchachi being a much younger cycle in the Upper Paleozoic. Unfortunately, both hypotheses were in accord with known data: the only known fossils were from high in the upper Mucuchachi and any known lower section was metamorphosed. We hoped, as one of many objectives during this field trip, that the concept of time-equivalency would be supported by obtaining fossils from some unreported outcrop of the lower Mucuchachi formation. We therefore planned to search for another outcrop, north of the type localities of Mucuchachi and Caparo formations, somewhere southeast or northeast of El Morro in the Los Nevados mountains. If some diagnostic fossils were found it would be scientifically important and would be a real scoop for the study (we had a marvelous scoop during the field study on Trinidad by finding an unreported oil-seep in a previously unconsidered area).

As everyone knows, in field work Murphy's Law and the Law of Threes often prevail. First, we had the flooded carburetor in high-speed heavy traffic,.......now what?

Our evening arrival in El Morro was unexpected. The letter, sent months ahead, had not made it up the trail from Merida ("through rain and.......", but not the El Morro trail); and so the lady of the Inn was rushing around cleaning and preparing a meal on hearing of our late arrival. Nobody minded, and the local rum helped to cheer our spirits, but worse was yet to come. The rains had washed out the pathway to the south and some mules and the muledriver had colds. High here in the Andes, it seemed everyone was infected with a hacking cough ameliorated to some extent by rum. A hurried conference was called, along with another drink, to decide tomorrow's action. Life, here in the Andes, is simple and stressless, and solutions to problems are obvious..........bolivars changed hands ....we were on our way with fresh mules, a baggage donkey, and two short horses. We also changed the route; it was now along to the village of Los Nevados (2,711 m) for an overnight stay, and then onto the Merida Teleferico (a cablecar) at Loma Redonda, a two day mule ride of 18 hours. At Loma Redonda (4,250 m), the cablecar down to Merida (1,577 m) takes 40 glorious minutes from hell, with only two stops in between. The cablecar, the longest and highest in the world, travels 12.5 km. At it's highest station there is a beautifully carved statue of the Virgin of the Snows on a large pedestal, but off in the distance, there can be seen the snow-covered top of Pico Espejo (4,765 m), crowned by a huge bronze statue of (you've guessed it) the ubiquitous Simon Bolivar.



The 12.5 km long *Teleferico* at Lomo Redonda at 4,250 m (13,950 ft). (Photo courtesy Retog Inc.)

The sun rose, ending the noises of the cockerels and dogs. I had previously heard of crowing and barking during the night in the Caribbean, and that was to drive away the mongoose from the hen houses; but why here, up in the mountains? These were not the only new noises I would hear in the next few days.

As we stepped outside, the morning sun blinding us, we found that we could move normally at this altitude - but realized that higher up our breathing would be very much heavier. We collected our baggage and dragged ourselves uphill through the village and around Simon Bolivar square to the start point about one mile from the inn. This part of the journey was exhausting and we must have looked like mules (asses?) to the local population. I still wonder why the mules or at least the baggage donkey did not come to us, but the guide said that this would expedite things. Some of the young gung-ho members of the party, eager to start, managed to convince the guide and muledriver to help them with their bags, leaving us bigger, slower and older members to struggle along with the cameras and packs. By the time we assembled at the start point, we were sweating and breathing hard. Coats and heavy jackets were removed, sun lotion heavily-applied, and hats put on in the strong sunlight and slight breeze. Children and some adults and old men came out of their houses to see us go, and I could not help wondering if they too thought we were crazy.

Where were the mules?

Having breakfast of course. The muledriver went to harness the animals and the guide placed all the baggage onto two large fish-net bags that he tied together like two large balls. Everything on our side seemed to be ready now.

Where were the mules?

An animal appeared that did not look like a horse, was gray in color and unshod. I quickly looked at its back to see if he had the markings of the cross that determines a donkey. There they were.....but everyone said it was a mule. Wait a minute, I had seen many donkeys and this certainly was one. Suddenly the animal saw the baggage, backed away and brayed. I knew I was right. The guide laughed and with the muledriver loaded up the baggage onto its back. The baggage must have weighed about 150 kilos and then we added watermelons and other edibles and some plastic cups for our lunchtime break.

Where were the mules?

The two younger members were now chafing-at-the-bit and eager to get started. Someone suggested that perhaps they should walk on ahead and we should catch up with them with the mules down the pathway. Okay, that sounded good to me........I could see ahead the steep upward path made for climbing rather than walking, and I was already feeling the altitude. So it was decided that the two *rambos* go on ahead and I and my colleague should go in style. Ten minutes later we could still see them struggling up the steep slope, stopping many times to rest but not admitting defeat. They passed out of sight.

Where were the mules?

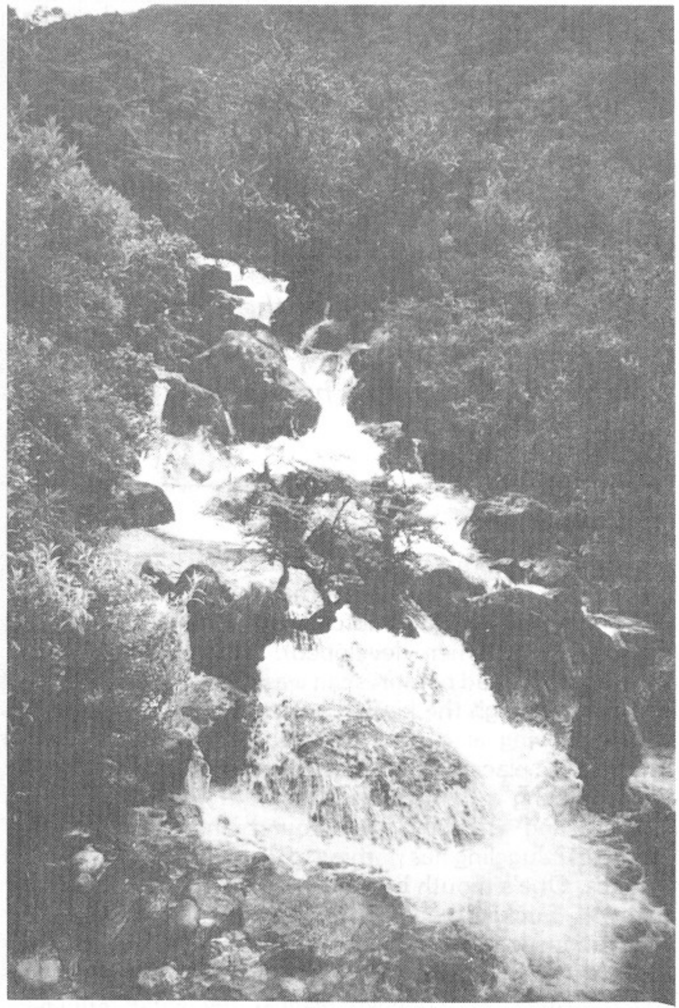
At last, some dark-brown sturdy looking animals appeared. I looked at the thin legs on one and thought I had better choose the stronger looking one. It seemed gentle enough and stood silently by as the saddle was tightened and the stirrups lowered to their fullest extent. This was it. My first ride. Okay, now to get on......and stay on. I hung my camera around my neck and down my back and leant all my weight onto my right foot in the stirrup. I conjured up memories of John Wayne.....and memories too of the circus clowns who mounted right over the animal onto the ground at the other side. Up I went and sagged down again. The saddle, it seemed, was not tight enough and slipped towards me. No problem.....the muledriver held onto the pommel and indicated to try again. I grabbed the saddle and swung this time up and onto the animal. Hooray! I made it; now to get balanced and hang on. My partner was not so lucky. The mule was not having him on his back at any cost. The guide and the muledriver tried to quiet the animal, but gave up in the end and decided on the horses. No problem here. He was soon mounted on one of these small-as-a-mule sleek-skinned animals. The lunchtime watermelons were then transferred along with some bags to the recalcitrant mule. We were off!

The *rambos* had nearly an hour headstart. Surely we could make that up soon with these animals and at this altitude. We approached the first slope. The donkey was in front, the horses next and the two mules behind, followed on foot by the muledriver. I wondered why........not for long.Up the slope we went. Halfway up my mule decided that he had had enough. He stopped. I urged him on. No go. I flicked the reins on his rump. No go. He turned and looked at me, still chewing on the bit. Have you ever noticed how soulless a mule's eyes are? Everything I tried, including digging in the heels as in a rodeo, did not work. Even sounds like *gee-up* and clicking of the tongue had no effect. Sud-

Outcrops along the trail in the clouds at 4,000 m (13,000 ft). (Photo courtesy Retog Inc.)

denly he moved, or rather jerked forward, at the same time as I heard a strange low kissing noise. It was the muledriver making this peculiar noise that had an immediate effect on the animal. I hung on, my fingers grasped around the pommel, trying to maintain my balance, as the animal surged past the horses and up the hill and over the top. The horse had a hard time of it, slipping and sliding on the loose rocks that appeared to be an uphill river course. Over the brow of the hill was a long downward trail for about two kilometers, and then up again. The drop-off descended about 1,000 m. and I had some problem hanging on while lying on the back of the mule. There was a shout behind me.........no time to turn around now.......but how do you stop this machine ....it was on a roll and nothing appeared to want it to stop except reaching the flat ground at the bottom. I hung on......the mountainside opposite flashed upward.........my legs and fingers hurt with the tension......sweat rolled......the sun was hot......no noise from me, just the mule's hooves crashing against the rock rubble as it slid and stumbled down the slope. At last silence and no movement. We made it! Godamn, I made it! My tension went, and I sat up in the saddle and looked back.

Far above were the horses, riderless, and some figures waving at me. The donkey had made it and was nearly upon us. We moved to one side and let him pass, and immediately my mule followed, down to a mountain stream for a drink. I needed something stronger. I waited atop the mule as he drank, knowing full well that it was impossible to get down from this saddle without some help. A few minutes later the others joined me. They were on foot, and my colleague and the guide intended to stay that way. They could not stop chattering about this near-miss and the risk we were taking on these hills riding the horses. It was not so much the climb up but the clamber down that was potentially so catastrophic and risky.



One of many mountain streams used as drinking sources for mules and humans. (Photo courtesy Retog Inc.)

I knew then that I was going for the mule-riding championship.

I had already learnt who was master, who was in charge, and what was the pecking order on the trail. One thing was evident; the muledriver did not want us dismounting at anytime on this path. So here I was, technically out of control - at the mercy of an animal with soulless eyes. I gazed ahead. The path climbed upward for about 1,500 m. I realized that for the next two days I was a prisoner on the back of a beast that controlled my destiny with its feet.

Suddenly there was a commotion up ahead. The donkey carrying all the heavy baggage had decided to get amorous with one of the horses. Good grief!...he was trying to mount the horse with all our baggage on his back......now that's a sex drive for you! The muledriver shouted and whacked the donkey back to reality. We were all stunned. We were learning so much about life-without-rocks on this trip.

I made it up the next mountain, with the others trailing behind. From the top we could see the two *rambos* in the distance, about 2 km away as the crow flies or about 10 km on the ground. The second mule came in for good use though, not for riding, but for pulling the guys along with its tail. Hour after hour went by, but still we were either climbing or descending and crossing streams and climbing again. We visited many outcrops along the way and collected samples. Collecting rocks is easy at these outcrops......one merely leans over on the mule and grabs a sample or hits the rockface with a hammer and lets the others collect the sample from the ground as they pass. Sampling high on the outcrop was simple. Taking photographs was another matter, unless you had wings or a macrolens. The pathway was so narrow and the rockface so close that only oblique photos were possible (which were not very good when developed). Another photographic problem that I had not foreseen was changing film on top of a mule. Although the kissing noises were great to get this hybrid moving at a trot, one always ran out of film at unfortunate places, either uphill or downhill. Have you ever tried opening a camera back while trying to keep your balance and watching the ground ahead for potential stumbles? Juggling has nothing to do with it, but that's what it takes. One's mouth becomes a great place for the used film roll. Luckily I had an automatic roll-on camera for one-handed loading, except that the zoom lens always was in the way of the pommel (my only security blanket on this rollercoaster), and banged against my white knuckles. Once, I nearly swallowed a 36 roll of Ektar while loading a 36 roll of Gold. That metallic residual taste of the cartridge and the felt-opening remained until lunch. Another problem, cured early on, was trying to take video. Absolutely impossible.....unless you wanted spectacular shots of the mountainside as you flew past on your downward trip. Balancing, looking through a viewfinder, and trying to keep the camera steady on the move requires at least four hands and one's butt superglued to the saddle. So after the first mountain all the large camera equipment was stowed away carefully and I made sure that it was on the outside of the donkey so that it would not be scraped against the rock face along the trail. Unfortunately that move was not too bright. The mule and the donkey raced for leadership, bumping together, and forcing their way past us on the narrow trail. Those cameras and equipment can hurt, especially the tripods.

"Collecting rocks is easy at these outcrops...one merely leans over the mule and grabs a sample or hits the rockface with a hammer and lets others collect the sample..."

Finally, after what seemed like all day, we stopped for lunch. The two *rambos* were waiting for us and both helped me to the ground as my legs were kind of locked in the stirrups. I staggered up the hill a short way, following the others to an abandoned shell of a farmhouse, where we were to rest for an hour out of the cold wind that had just started blowing as we turned the final bend to the stop. We were all hungry but even more thirsty. Everyone wanted water. The guide passed out the plastic cups and everyone waited in anticipation.Suddenly, even the horses were quiet, the guide announced that someone had forgotten the water. Oh my God! Murphy's law was alive and well in Venezuela! No water.....impossible......how about the watermelons! We all pounced on those large green footballs with our knives drawn. As luck would have it, the older and wiser members waited until the younger ones hacked theirs to bits. They were sour. The strong sun's rays had done a number on our only water supply. Well, nothing for it except to chew on some US-made jerky. Big mistake! Our thirst only increased. We were really badly dehydrated. We looked at one another and knew instinctively that we had the same thought.......we were going to have to drink at the mountain streams, just like the mules. The water tablets were in a bag deep in the baggage down the hillside, and nobody wanted to dare unload that mule (what a kicker - he should have played for the Cowboys!). We had heard all the stories and read all the books.....but here we were.....and after all, the locals are OK........or were they? Well, here's mud in your eye! One month's time will tell. I could not remember if it was the bacteria or the worms (I remember the worms in China)......too bad, pass the rum, it should kill anything.

After the non-lunch (except for some jerky and many gallons of water from a waterfall pouring off the mountain), we all set off again, our target, Los Nevados, somewhere out there in the far blue yonder. My legs were better and some feeling had returned to my white fingers, but the base of my spine was still very tender. I mounted my steed (was I just another piece of baggage again to him?) and set off after the others. The weather had changed, of course, as we went higher. The rain started and the wind chilled us through our shirts. We all put on plastic coats; but, exposed high up on the mule, the wind chilled all my exposed parts including my tightly-gripped hand which was wrapped around the pommel. My mule just put his head down and plodded on.

The terrain became more level and I took the opportunity to adjust my butt on the saddle, first one cheek then the other. I also tried standing in the stirrups to keep the circulation going in my legs. This was not too bad and we were making good time, this time across the hills, not up and down. But all good things come to an end. After a few hours we started back down the hillside and across bridges and through some small communities to start the final ascent to Los Nevados. For over 9 hours I had been staring at the ground and ears of the mule. This animal was my life. Its mane was short but full with a small white spot between the ears. His ears seemed healthy and intact. I always heard that when fighting, these animals bite the ears. Mine must have been a champion; he even bit the horses when he could. I tried to stroke the ears but although soft on the inside they were bristle-like on the outside. The mule was not amused. He turned his head to look at me and bared his ugly yellow teeth......as much to say "hands off man! unless you want off". I quickly returned to being a piece of baggage as we moved slowly but surefootedly up the mountainside and on to Los Nevados. Ahead, I could see Los Nevados, but it was another hour before I could fall off this beast and crawl to the inn.

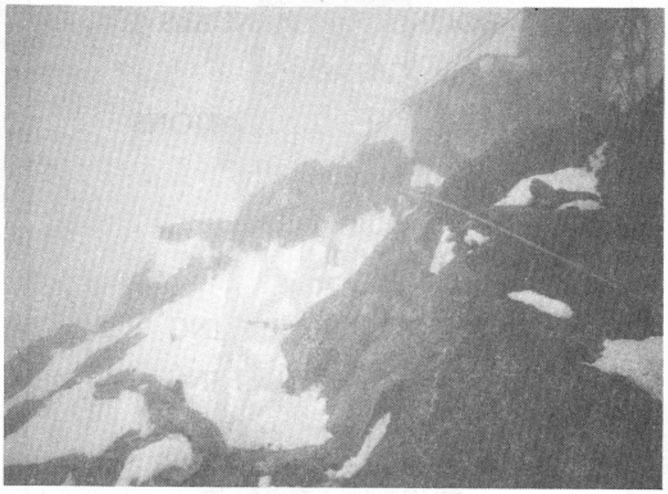
Los Nevados: sounds like a lost goldmine in New Mexico doesn't it. This was no goldmine, but it was a stop, even though cold, wet and unbreathable at 2,711 m. We entered the village from downhill, moved around the inevitable Simon Bolivar square with church, and continued the climb up the hill to the inn. One of the *rambos* had run ahead and was waiting for us with cold beers in hand when we arrived. Boy, that beer tasted good........and I hate beer. The overnight inn was really a courtyard surrounded by a building, like an enclosed lean-to, opensided at one end for the kitchen and at the opposite end for a mountain-water bathroom. In the kitchen a cheerful lady in a blue parka was cooking something on a gas stove, and had made hot coffee for our arrival. The night was spent in a communal room, and after our stew supper we were all in bed, (some asleep with exhaustion) by 6:30 p.m. Some first braved the cold mountain-water shower; while they screamed, we laughed. We slept till dawn. Breakfast was eggs and coffee, consumed with haste as we gathered our gear and made our way uphill to join the waiting mules.

Today was different, I could tell. The mules were ready.

Today all of us had to ride mules and horses for this was a very hard steep climb, to over 4,000 m, across loose rock and dangerous pathways. No walking was possible over most of the track through the gullies and up the mountainsides. We started out together: I thought it was the Kentucky Derby as all the mules and horses dashed for leadership and jostled and barged their way through. When you bump against another animal it's not too bad, but to hit another's leg and stirrup is something else. Crushed and scraped legs make you a little mad, and everyone shouted to keep one's distance. But who's in charge? Not the rider. Each animal was its own boss and decided who it was going to follow and was going to get in that position at any cost. Some riders thought they could control their animals and tried to steer and guide, to no avail, but with much swearing and cursing. At last the column settled down and we all fell silent and nursed our bruises. This bumping and jostling always seemed to occur on the steepest slopes or the narrowest trails. I was fortunate to have a bigger mule and a more comfortable saddle: wow, I needed this as my spine and derriére were still sore from yesterday. The mule was docile enough and I could govern its forward speed by using kissing noises, but it insisted on following the baggage donkey every step. Later I learnt he was a leader and every other mule was following him. I was aboard the king (King of the Asses?), and everything would be all right as the other animals seemed to leave him alone, with respect.

Suddenly one of the horses made a quick dart up the slope immediately in front of my mule. Danger! Danger! This was the king. My mule was mad. No overtaking here. He spurted up the steep incline right up behind the horse and bit him on the rump. The horse reared up. My mule turned around and lifted up his hind legs. The horse slid down the slope, rider and all. I was left perched on the mule on the edge of the slope facing the wrong way and breathless. The mule brayed and resumed his leadership position. The other animals continued as if nothing had happened, and the horse, with the rider remounted, continued once again up the slope.

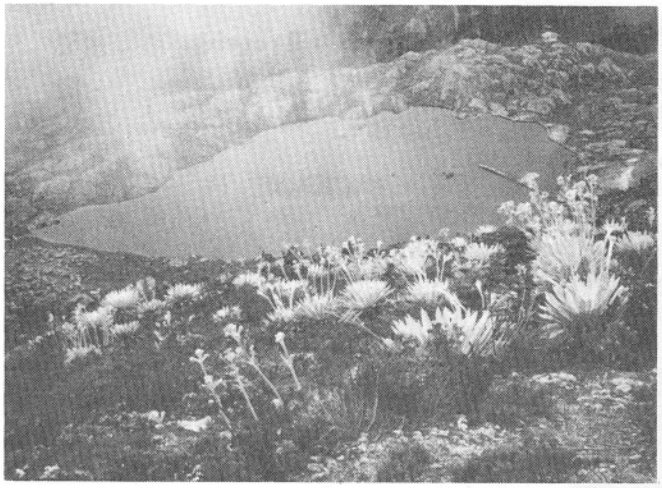
After 6 hours of sunburn, freezing wind, cold rain and no water (except for the mountain streams), we moved along the final kilometer and saw the large Cross of the Andes, along the *paramos* (high pass) atop the highest ridge, marking the highest point of our trail. We were passing along the core of the Andes. The metamorphosed rock glistened in the sunlight......it also glistened in the rain and mist,.......on the track, in the outcrops and on the distant hillsides. So this was the Caribbean Series silvery mica-schist of ?Pre-Paleozoic - Paleozoic age. There must be more than 1,000 m exposed here. The mountains are composed of a granite core covered by schistose and gneissoid metamorphics: the metamorphism occurred during the Carboniferous.



This last kilometer was a killer; no way could you walk. The trail was a moving slope of rock. Thankfully, the mule knew where to tread, funnily enough, following the donkey's steps. No fool this mule. If the donkey fell, then the mule wouldn't. We literally slithered up the shiny loose rock bed, weaving our way back and forth, across and up the narrow valley between two high shear-walled peaks. At this height the animals only took about four steps then rested a moment before continuing the climb. My mule never took his eyes off the trail, while four feet in front of him the donkey was wheezing and puffing with his heavy load: certainly not the time for thoughts of sex. The Cross loomed ever closer in the mist: we were near the end, I thought.

Not quite. At the top we all dismounted and rested. This was as far as the mules would go. It was time to say goodbye to my mule: but don't expect hugs and kisses from me, you beast. We were now our own *King of the Asses*. Down a few hundred meters and about two kilometers away, around La Cueva de Calderon (a beautiful lake),

through some *coloradito* trees growing in sheltered spots (a tree growing at the highest altitude in the world), and on to the *teleferico*. Our journey was over. We had left the *beasts of burden* (or was it *beasts of hell?*), and were now in the safe clutches of civilization and in control of our own destiny.



La Cueva de Calderon **(Crater Lake) with *Coloradito* trees at 4,250 m (13,950 ft).**
(Photo courtesy Retog Inc.)

HUGH J. MITCHELL-TAPPING—Biographical Sketch

Hugh J. Mitchell-Tapping is a member of HGS. He received a B.A. in geology from the University of St. Thomas, Virgin Islands, and M.S. and Ph.D. degrees from Florida State University. He has worked for Amoco, Sun, and Hunt Oil Companies, where he spent numerous years overseas, including three years in China. Dr. Mitchell-Tapping has over 50 publications and seven books to his credit. He lives in Dallas, where he is a consulting geologist.

HGS MODERN CARBONATES FIELD TRIP
CANCUN, MEXICO
NOVEMBER 5-8, 1992

This will be a self-directed field trip to study recent carbonate sediments and Pleistocene and Holocene outcrops in the Cancun area. The cost of the trip is $400.00. This includes air transportation by Aeromexico, three nights hotel accommodations at the Cancun Viva and guidebooks. Participants will be responsible for their own snorkeling gear. The trip will begin at Houston Intercontinental Airport on Thursday, November 5 and participants will return on Sunday, November 8, 1992. Spouses and guests are welcome.

Send registration forms and checks payable to:
Houston Geological Society
7171 Harwin, Suite 314
Houston, TX 77036-2190

For further information, please call Gary Moore at 975-2753 or Gail Bergan at 932-7183.

Registration Form
HGS Modern Carbonates Field Trip

Name: ______________________

Address: ______________________

____

Company: ______________________

Phone: ______________________

ENVIRONMENTAL/ENGINEERING GEOLOGISTS

HGS ENVIRONMENTAL/ENGINEERING COMMITTEE DINNER MEETING JUNE 10, 1992

Time: 6:00 - 6:30 p.m., Social
6:30 - 7:30 p.m., Program

Location: Italian Market and Cafe
2615 Ella Blvd.
(behind Memorial Northwest Hospital)

Speaker: Ed Shaw, President
Environmental Consulting and Design

Subject: Groundwater Treatment Using
Advanced Membrane Technology

Career Change Networking Group will convene at approximately 7:45 p.m.

During the summer months the Career Change Group will continue to meet twice a month (see schedule below) at 6:00 p.m. at the offices of Groundwater Technology. Call Bob Rieser for directions.

Meeting Dates:
July 8 and 22
August 12 and 26

40-HOUR HAZARDOUS WASTE SITE OPERATIONS TRAINING

Date: June 1-5, 1992

Time: 8:00 A.M. - 5:00 P.M.

Cost: $475.00 - HGS Member
$700.00 - Non-Member

Presented By: Environmental Education Services, Inc.

OSHA-required training for all employees who work with hazardous material at Superfund sites or other uncontrolled hazardous waste sites.

The following topics are included using lectures, demonstrations, comprehension quizzes and numerous hands-on sessions:

- REGULATION REVIEW
- TOXICOLOGY
- PROTECTIVE CLOTHING/EQUIPMENT
- SITE SAFETY/HEALTH PLAN
- SITE EMERGENCY RESPONSE
- MONITORING
- CONFINED SPACE ENTRY PROCEDURES
- HEALTH HAZARDS
- PHYSICAL HAZARDS
- RESPIRATORY PROTECTION
- WORK PRACTICES
- MEDICAL SURVEILLANCE
- DECONTAMINATION
- SPILL CONTAINMENT PROGRAM

Participants will receive:
REFERENCE MANUAL
PERFORMANCE CHECK LIST
RESPIRATOR FIT-TESTING
WRITTEN TEST
LEARNING ACTIVITY PACKAGE
SET-UP AND PERFORM
DECONTAMINATION
COMPLETION CERTIFICATE

Limit: 25 participants.
For more information call (713) 261-6340.

24-HOUR HAZARDOUS WASTE SITE OPERATIONS TRAINING

Date: June 8-10, 1992

Time: 8:00 A.M. - 5:00 P.M.

Cost: $295.00 - HGS Member
$450.00 - Non-Member

Presented By: Environmental Education Services, Inc.

OSHA-required training for all employees who work with hazardous material at Superfund sites or other uncontrolled hazardous waste sites.

The following topics are included using lectures, demonstrations, comprehension quizzes and numerous hands-on sessions:

- REGULATION REVIEW
- TOXICOLOGY
- PROTECTIVE CLOTHING/EQUIPMENT
- SITE SAFETY/HEALTH PLAN
- MONITORING
- HEALTH HAZARDS
- PHYSICAL HAZARDS
- RESPIRATORY PROTECTION
- WORK PRACTICES
- MEDICAL SURVEILLANCE
- DECONTAMINATION

Participants will receive:
REFERENCE MANUAL
PERFORMANCE CHECK LIST
RESPIRATOR FIT-TESTING
WRITTEN TEST
LEARNING ACTIVITY PACKAGE
SET-UP AND PERFORM
DECONTAMINATION
COMPLETION CERTIFICATE

Limit: 25 participants.
For more information call (713) 261-6340.

HOUSTON GEOLOGICAL SOCIETY
ENVIRONMENTAL/ENGINEERING GEOLOGY COMMITTEE

To date the HGS Environmental/Engineering Geology Committee has provided assistance to those interested in changing careers from the petroleum industry to the environmental industry by focusing on three areas:

1. Seminars on fundamentals such as regulations, drilling and sampling.
2. Technical field trips and talks at monthly dinner meetings.
3. Listing career change opportunities.

Additionally, the E/EG Committee is currently compiling an industry employment database to provide potential employment information on environmentally-related companies. If you would please take the time to fill out and return the questionnaire it would be greatly appreciated.

Also, if your organization will be hiring highly qualified and motivated professionals in the future, the HGS Personnel Placement Committee would like to assist in your employment needs. Call (713) 785-6402.

HOUSTON GEOLOGICAL SOCIETY
ENVIRONMENTAL/ENGINEERING GEOLOGY COMMITTEE
INDUSTRY QUESTIONNAIRE

Company Name: ______________________________

Address: ______________________________

____

____

Is this the corporate address? ☐ yes ☐ no

Is this a branch office? ☐ yes ☐ no

Primary business of Company: (Please check only one.)

______ Educational ______ State or Federal Agency

______ Consulting ______ City or County Agency

______ Treatment, Storage, Disposal ______ Other; please specify ______________

Are there job openings at your company? ☐ yes ☐ no

These positions are available for:

______ Geologists: ______ entry level ______ experienced

______ Engineers: ______ entry level ______ experienced

______ Salesmen: ______ entry level ______ experienced

______ Managers: ______ entry level ______ experienced

______ Other; please specify ______________

Name of contact or hiring authority: ______________________________

Telephone No.: ______________________________

Would you be willing to talk with someone from the Houston Geological Society concerning the potential job openings noted above? ☐ yes ☐ no

Your name: ______________________________

Telephone No.: ______________________________

PETROLEUM STORAGE TANK REMEDIATION FUND*

To address the problem of expensive petroleum storage tank clean-ups, the state, on May 31, 1989, created the Petroleum Storage Tank Remediation Fund. This fund is financed by fees for registration of tanks and a fee on bulk distributors of petroleum products based upon the volume handled. The fund collects about 65 million dollars per year.

The fund was set up for two main purposes: (1) to help owners and operators satisfy state and federal financial assurance requirements with regard to environmental pollution, and (2) to be a source of the extraordinary financial requirements to clean up the mess. The fund operates as a kind of insurance policy where premiums are paid by all gasoline users. The fund will reimburse owners or operators for certain costs of clean-ups with a $1,000 to $10,000 deductible and a million dollar cap (per occurrence).

The fund also pays for state-contracted consultants who will do clean-ups at the direction of the state and be paid directly by the state. The state has selected six regional contractors and two state-wide contractors for this purpose. Each contract was initially for one million dollars and some have been extended to six million.

In addition, as a matter of policy and practice, the Commission has set up procedures to give some assurance to lenders that a borrower is eligible for reimbursement from the fund prior to the time a loan for clean-up activities is made. These actions should free-up a source of private funds to accomplish clean-ups. Moreover, the Commission has adopted rules to allow lenders, insurance companies, and subsequent owners of property on which pollution from petroleum storage tanks is found, to become agents or assignees for persons who may make claims on the fund. This should encourage additional clean-up funds from these private sources.

The particular provisions that will be discussed can be found in S31 TAC 334, Subchapter H. This subchapter was previously adopted on an emergency basis in January of 1990. The permanent (interim) rules were published June 13, 1990. They became effective on September 26, 1990. They were amended in the summer and fall of 1991 to incorporate the changes in H.B. 1214. These rules now cover the period from September 1, 1987 until the date the final period rules are adopted. We anticipate that final period rules will be adopted later. We do not expect substantial changes to occur in the final period rules.

The first major provision of the rules is that **reimbursement** is required, not direct payment to contractors. Thus, a claimant (owner or operator) must have paid the bills, not merely owe a clean-up contractor. The reimbursement must be for the costs of environmental clean-ups, not personal injury or property damage. There are two important exceptions. The fund may be used to provide water to replace an impacted water supply, and the fund may be used to clean up others' property.

Being intended for remediation, the fund will not pay for upgrades of an underground storage tank system. The fund will pay between one thousand and one million dollars per occurrence. A single owner may have more than one occurrence and more than one occurrence may transpire at a single site. Indeed, a single tank may have more than one release occurrence although this is frowned upon.

The costs for which reimbursement is sought must be reasonable and necessary. This means that if the owner selects a type of remediation technology which is more costly than an alternative technology which will do the job, the fund will only pay what the less expensive technology would cost. In addition, within the appropriately selected technology, the fund will only pay for reasonable and necessary costs. If three monitoring wells will do the job, the fund will not pay for five. If the costs of the three are beyond the typical cost of wells for this particular geology and location, the fund will only pay the typical cost.

Currently, the fund will pay **owners** and **operators** of tanks and their agents or assignees if they are a lender, insurance company or real estate purchaser. The fund will also pay persons whose land has been polluted by releases from tanks. The fund will not pay contractors who have expended money on behalf of owners or operators.

If a previous owner removed the tanks, but left the pollution and you bought the property, if approved by the TWC, the fund will reimburse you if you cleaned up the pollution. If you could convince the previous owner to clean-up the site (by agreement, threat of lawsuit, etc.), that person could access the fund. Or you, the subsequent property owner, could access the fund to complete the remediation work begun by the tank owner by executing an agency or assignee agreement with the owner.

The fund will not pay for reimbursement for remediation which occurred prior to September 1, 1987.

The fund pays for remediation of "releases". Releases include overfills. However, the contamination must be above action levels and must go beyond the excavation zone to be a release unless clean-up within the excavation zone is ordered or agreed to by the Commission. The release must be from the tank system, not monitoring wells or the delivery truck.

The rules also set out certain minimum eligibility requirements for claimants: (1) the claimant must be an

*Extracted from an article entitled "Underground Storage Tanks" by Ramon E. Dasch, an Attorney with the Texas Water Commission. Originally published in the TWC Trade Fair and Conference Seminar Notes, April 1-3, 1992, Houston, Texas.

owner or operator of a tank; (2) all tanks that the claimant owns or operates must be registered; (3) all fees must be paid; and (4) the release must be reported to and confirmed by the Commission.

The rules further delineate categories of allowable and non-allowable expenses. It should be observed that not every necessary expense is allowable. Allowable expenses include remediation and disposal costs, costs of tests and monitoring, costs of access to others' property, replacement water supply, relocation of utilities, preparation of reports, sales taxes on remediation equipment and materials, the cost of time spent by an applicant administering the applicant's own remediation effort (if there is no other person such as a consultant or general contractor who is performing this function), and certain interest costs on borrowed money to finance petroleum storage tank clean-ups. These interest costs are limited to interest on the (borrowed) amount after the day the item is approved for payment in the Executive Director's Fund Payment Report.

Non-allowable expenses include costs of tank replacements and up-grades, loss of income or profits, decreased property values, third party damages, attorney fees, costs of enhancement of the property beyond restoration of its original status, and costs of remediation of releases from underground storage tanks of non-petroleum products. "Petroleum product" is a term of art defined in the statute. The most significant restrictions in the definition are the exclusion of jet fuels and the requirement that the product must be capable of being used as a fuel for the propulsion of a motor vehicle or aircraft.

The fund will now pay for the clean-up of spent oil from automobile crankcases, transmission fluid and brake fluid, as well as mixtures of spent oil and other contaminants if those contaminants are due to the normal use and contamination of spent oil due to that use.

The fund will also pay for clean-up of hydraulic oil releases. In both cases (spent oil and hydraulic oil), the releases must occur at vehicle fueling and service facilities.

The fund will not pay for remedition activities which are not conducted in accordance with applicable environmental laws.

POLLUTION REPORTING HOTLINE

WHAT:

A toll-free number to report pollution: 1-800-3 OUR BAY.

WHY:

To make it easier for citizens to report pollution to the proper authorities.

WHERE:

Anyone in the five counties surrounding Galveston Bay—Brazoria, Chambers, Harris, Galveston and Liberty Counties—may call the hotline to report pollution.

WHEN:

Twenty-four hours a day.

WHAT KIND OF POLLUTION:

Land and water debris, oil and hazardous substance spills, fish and bird kills, bilge pumping, air emissions, groundwater contamination, storm drain dumping, improper waste disposal and any other activities that may produce pollution. If in doubt, call.

HOW IT WORKS:

Callers will be asked to describe the details of the pollution to an operator who will then contact the proper authorities and track the complaint through final resolution. Callers will receive a written reply describing the resolution of their report.

WHY A HOTLINE?

Citizens rarely know who to contact when they witness pollution or activities that degrade the environment. With multiple agencies having jurisdiction over environmental affairs there is no centralized reporting mechanism. The hotline enables the citizen to make one call and see results without being transferred to multiple persons and agencies.

In addition, data on pollution will be collected and assembled into an annual report to the legislature detailing problem areas and gaps and overlaps in the regulatory structure.

WHO IS PAYING FOR IT?

The hotline is a demonstration project of the Galveston Bay National Estuary Program (GBNEP), which is a consortium of state and federal agencies, local governments, environmental and citizens' groups, commercial and industrial interests, and recreational users of the Bay. The GBNEP's purpose is to build a consensus toward developing a Comprehensive Conservation and Management Plan for Galveston Bay. Funding is 75% Federal, 25% State of Texas.

FOR MORE INFORMATION, CONTACT:

Samra Jones-Bufkins,
Public Participation Director, (713) 332-9937
or
Karen Pierce,
Hotline Coordinator, (713) 332-9937

HGS ENVIRONMENTAL COMMITTEE/ NGWA VIDEO FEST

Date:	June 17, 1992
Location:	Barry's Pizza 2214 Mangum (South of Hwy. 290)
Time:	6:00 - 9:00 p.m. Programs begin at 6:30 p.m.
Cost:	None, purchase own dinner/drinks

Come enjoy dinner and/or a beer(s) at the HGS Environmental/Engineering Geology Committee's first National Ground Water Association (NGWA) Video Fest. We will be showing two videos (see below) from the NGWA library at no charge. (Barry's Pizza hopes to make some sales, however, otherwise they will charge the committee $400 for the use of the room.) The videos will be shown on the restaurant's big screen.

- 1990 Darcy Distinguished Lecture Series Video
  Ralph C. Heath
  Hydrogeology and Hazardous Waste Disposal
- 1989 Darcy Distinguished Lecture Series Video
  Dr. R. Bassett
  The Utility of Chemical Modeling, With and Without Advection, in Natural and Environmentally Stressed Hydrologic Systems

ENVIRONMENTAL NOTES

LAND DISPOSAL RESTRICTIONS FOR DEBRIS*

EPA proposed land disposal treatment standards for hazardous waste debris in the January 9, 1992 *Federal Register* (57 *FR* 958). The treatment standards for debris are expressed as treatment technologies as opposed to chemical concentrations because of the difficulty in measuring the concentration of hazardous waste constituents in a variety of materials. It is expected that the debris treatment standards will be finalized in May 1992.

Treatment standards are to be established under the RCRA land disposal restrictions (40 CFR 268) for every hazardous waste code. Hazardous waste cannot be treated or disposed in a land-based unit (landfill, surface impoundment, or waste pile) unless the hazardous waste meets the treatment standard. Treatment standards are expressed either as a technology that will achieve best demonstrated treatment, or as chemical concentrations. Treatment standards were established based on industrial hazardous waste streams. However, these standards are also applied to debris, soil, and groundwater. Because of the physical and chemical differences between a waste stream, debris, and soil, EPA is proposing treatment standards specifically for debris, and later this spring will be proposing treatment standards for soil.

Treatment standards for debris take into account the physical characteristic of the debris, available treatment technologies, and the type of contaminant. Seven categories are established for the physical characteristics of debris: metal objects; brick, concrete, rock and pavement; wood; rubber and plastic; paper and cloth; glass; and miscellaneous, including radioactive and PCB contaminated debris. Three treatment technology categories are established: extraction, destruction, and immobilization, and within these categories, eighteen specific treatment technologies are established. Treatment technologies include washing, incineration, vapor phase solvent extraction, biodegradation, and others. Ten categories of contaminants are established based on similar physical and chemical properties. These categories include halogenated aliphatic compounds, non-volatile metals, dioxins, and others. The debris treatment standards appear complex but are clarified in a table (57 *FR* 1023) with the contaminant category and treatment technology listed for each physical category of debris. A sample of the table follows.

DEBRIS TREATMENT STANDARDS

Contaminant category and treatment technology	Metal objects	Brick, concrete, rock, pavement	Glass	Wood	Paper, cloth	Rubber, plastic
Halogenated Pesticides and Aromatics						
Extraction						
Abrasive blasting	YES	YES	YES	YES	NO	NO
Acid washing	YES	YES	YES	YES	YES	YES
Destruction						
Biodegradation	YES	YES	YES	YES	YES	YES
Chemical oxidation	YES	YES	YES	NO	NO	YES
Immobilization						
Macroencapsulation	NO	NO	NO	NO	NO	NO
Microencapsulation	NO	NO	NO	NO	NO	NO
Dioxins, Furans						

Yes indicates acceptable treatment technology.

PRINCIPLES FOR SITE REMEDIATION ISSUED BY EPA*

An EPA work group has developed seven principles to guide remediation at sites where EPA is the lead regulatory agency. The principles were developed to initiate and promote changes to existing regulations that restrict site remediation. The principles form a basis for an integrated approach to remediation, and will contribute to reordering sites for remediation to achieve cost-effective risk reduction. The principles are:

1. The analytical process for making remedial decisions should be consistent throughout programs and sites while allowing flexibility to make site-specific decisions. This includes all aspects of the process, from site screening through final risk management decisions.
2. Requirements for storage, transport, and disposal of contaminated media and remedial wastes should reflect

*Reprinted from Groundwater Technology *RCRA/CERCLA Newsletter*, March 1992

the risks associated with the management of the waste. Where appropriate, this means that technical and procedural standards may differ from those that apply to non-remedial waste.
3. Remediation should be prioritized to limit serious risks to human health and the environment first, and then to restore sites to current and reasonably expected future uses, whenever such restorations are practicable, attainable, and cost-effective.
4. EPA's remediation programs should promote environmentally sound waste minimization and accelerated, effective cleanups by encouraging recycling, recovery, and the use of new technologies, and by removing administrative obstacles and other disincentives to voluntary action.
5. When empowering, funding, or delegating state programs, EPA should promote integrated remediation programs that are consistent with these principles. EPA should also provide flexibility to individual states in setting remedial priorities.
6. The remediation program requirements should facilitate enforcement and implementation of remediation.
7. EPA should provide effective two-way communication with the public, responsible parties, and other stakeholders regarding the objectives of its national cleanup programs, including the risks posed by contaminated media and remedial wastes, and the costs, benefits, and effectiveness of program decisions regarding remedial actions.

SOURCE: *Inside EPA's Superfund Report*, 1-29-92.

STATUS OF SUPERFUND SITE REMEDIATION*

The number of sites added yearly to the National Priorities List (NPL) has always exceeded the number of sites cleaned up and deleted. This continuing expansion of the number of NPL sites has resulted in citizens and Congressmen asking: "Are contaminated sites really getting cleaned up? How come it is taking so long and costing so much?" EPA is addressing these questions in a number of ways, including encouraging the use of innovative technologies and evaluating risk assessment.

EPA is encouraging the use of innovative technologies as it becomes apparent that the standard technologies of incineration, solidification/stabilization, and pumping and treating groundwater may not be as effective as previously believed. Also, standard technologies use treatment methods with limited capacity and may not destroy contaminants but simply reformulate and relocate contaminants. EPA is encouraging the use of innovative technologies in the following ways (OSWER Directive: 9380.0-17, June 10, 1991):

- At NPL sites where potentially responsible parties (PRPs) are taking the lead, EPA regions may identify and approve treatability technologies that would otherwise be considered unproven and too early in the development process. PRPs can use an innovative technology for EPA evaluation in conjunction with a standard technology that is specified in the Record of Decision.
- EPA is exploring the use of Federal facilities for both site-specific technology demonstrations and as test locations for evaluation of more widely applicable technologies.
- In addition to the SITES research program, EPA has requested applications for research leading to practical methods for enhancing the effectiveness of pump-and-treat groundwater recovery systems by improving the extraction of contaminants from the subsurface. Approximately $1 million will be available to fund five or six projects for a period of up to two years (57 *FR* 5453).
- A site-specific treatability variance, specified in 40 CFR 268.44 (h), can be obtained and used to treat hazardous waste soil to meet land disposal restriction treatment standards. Alternative treatment standards can be established for environmental media using Superfund Land Disposal Guide #6A (OSWER Directive: 9347.3-06FS, July, 1989).

Despite objections from PRPs, who previously were responsible for all site studies, risk assessments at NPL sites have been conducted solely by EPA since August, 1990. Previously, EPA was spending significant time modifying PRP risk assessments, risks were sometimes underestimated, and standardized procedures for conducting the assessments were not used. In July, 1991 EPA provided guidance which identifies the information which PRPs could provide to EPA for conducting the risk assessment. The information details the contaminants and the environment. PRPs still estimate residual risks associated with various remedial alternatives. EPA requested comments on the current risk assessment procedures in the February 20, 1992 *Federal Register* (57 *FR* 6116).

How many sites are on the NPL? How many have been cleaned up? The numbers follow.

NPL Sites	Total Number	Federal Facilities
Final	1183	116
Proposed	52	9
Deleted	40	0
Construction Completion	25	0

Deleted sites: sites that are cleaned up and no further response is required.

Construction completion category: sites that are awaiting deletion or the first 5-year review after remedial action has been completed, and sites undergoing long-term remediation.

ENVIRONMENTAL NEWS BRIEFS*

Mixture and Derived-from Rules: Reinstated - The mixture and derived-from rules were void February 19 after the U.S. Court of Appeals refused to reconsider its December 6 opinion that the rules were invalid because EPA had not sought public comment when it issued the rules in 1980. On February 19, EPA reissued the rules a interim final and intends to propose new rules in April 1992 after President Bush's 90-day moratorium expires. The new proposed rules may include concentration-based criteria for characterizing listed hazardous waste. Since the current rules will only remain in effect until April 28, 1993, EPA must promulgate final rules by that date.

Petroleum-contaminated Media Exemption - EPA is considering a regulatory amendment that would create a limited application of the TC rule to petroleum contaminated media and debris. The application of the rule would be

HGS ENVIRONMENTAL/ENGINEERING CONTINUING EDUCATION SHORT COURSES

Course Title: 1) CONTAMINATION PLUME IN ITS HYDROGEOLOGICAL SETTING
2) SITE CHARACTERIZATION USING CONE PENETROMETER TECHNOLOGIES

Instructors: 1) Dr. Ted Cleveland
2) Mr. Steven L. Schwartz

Date and Time: 1) Monday, June 29th, 1992 — 6:30-9:30 p.m.
2) Tuesday, June 30th, 1992 — 6:30-9:30 p.m.

Location: Paul Revere Middle School Auditorium, 10502 Briar Forest

Course Description: The first course outlines the general nature of contaminant plumes and the techniques to determine their extent and rates of movement, through the hydrogeological system.

The second course highlights conventional methods commonly used to characterize areas of affected groundwater, including soil borings, installing monitor wells, and water sample analysis. An alternate method in the forefront of technological advancement is the Cone Penetrometer. Innovatively used, it defines site hydrogeologic and groundwater quality conditions. Being both accurate and cost-effective, it can soon become extremely popular in an industry which holds these two parameters very dear.

Biographical Sketch of the Instructors: Ted Cleveland teaches at the Central Campus of the University of Houston in the Civil Engineering and Environment Department. He obtained his Doctorate and Master's degree from U.C.L.A. and his Bachelor's from Humboldt University. Ted's curriculum of instruction and research at U of H caters to environmental engineering and investigations in that field.

Steven L. Schwartz is a Project Manager for Fugro-McClelland's environmental practice. He is responsible for project design, for the supervision of technical quality of hydrogeological assessments and also of corrective action and closure plans. Practicing hydrogeology for fifteen years, he has done hydrogeologic evaluation of solid and hazardous waste sites, groundwater contamination and remediation studies and closure plan preparation and implementation.

Steven holds a Bachelor's in geosciences from the University of Arizona and has completed his graduate studies there in environmental geology.

Registration: Please mail your check to HGS, 7171 Harwin, Suite 314, Houston, TX 77036.

Total Cost: $20.00 ($10.00 for unemployed and underemployed members of HGS only)

For further information call Zubair N. Haq at 495-9828.

suspended for three years in states that do have legal authorities and administrative programs in place that provide for cleanup responses to petroleum releases, and controls on the disposal of waste generated from the cleanup. EPA is also considering several other requirements as prerequisites for suspension of the rule including a state certification program; states establishing specific cleanup levels for groundwater, soil, and sediments; treatment standards for waste generated from the cleanup; and pollution prevention programs for the petroleum industry. *Inside EPA Weekly Report*, 1-3-92.

Used Oil Regulation - A bill introduced to the House of Representatives by Representatives from Illinois calls for the regulation of used oil as a hazardous waste once the oil leaves its point of collection. Manufacturers of oil would be required to reuse the oil or fund someone to reuse it. The most controversial portion of the bill specifies that used oil with a lead content of greater than two parts per million should not be burned. This could eliminate most burning of used oil.

Effluent Guidelines will be Issued for 20 Industries - A settlement reached by EPA and the National Resources Defense Council includes a schedule for EPA to issue effluent guidelines under the Clean Water Act for the discharge of wastewater into U.S. waterways. Industries affected and year of finalization of the regulations are: pesticide manufacturing (1993); organic chemicals, plastics, and synthetic fibers (1993); machinery manufacturing and rebuilding (1996) and coastal oil and gas operations (1996). Other industries and wastewater effluents that will be evaluated include landfills and incinerators, industrial laundries, transportation equipment cleaning, petroleum refining, metal finishing, iron and steel, inorganic chemicals, leather tanning, coal mining, onshore/stripper oil and gas, and textiles. *BNA Current Developments*, 2-7-92.

Liner and Leak Detection System Requirements for Hazardous Waste Land Disposal Units Finalized - EPA has established final regulations for the technical standards of liners and leak detection system required of landfills, surface impoundments, and waste piles that receive hazardous waste. Most of the technical standards are already widely used because they are considered good engineering practices, required by HSWA, and are included in RCRA permits. 57 *FR* 3462, 1-29-92.

AAPG OFFERS SOMETHING FOR EVERYONE IN CALGARY

The AAPG Annual Meeting June 21-24 in Calgary, Alberta, Canada, will offer over 600 technical presentations, a "sold-out" exhibits hall and other special offerings worthy of note by the about 6,000 persons expected to attend.

Among the presentations will be the All-Convention Luncheon address by Daniel Yergin, who received in April the 1992 Pulitzer Prize for his book *"The Prize - The Epic Quest for Oil, Money and Power,"* a sweeping panorama of the history and personalities that shaped the oil industry.

Additionally, the Division of Professional Affairs-sponsored technical program will be a symposium on how significant geological plays have been taken from the concept stage, successfully funded and promoted, and have resulted in the formation of major new domestic and international independent oil and gas companies.

The specially invited speakers will discuss how they got their own companies going, what investors are looking for in an oil and gas deal, and give their advice on how to successfully market and finance significant new geological play concepts. After the formal presentations, there will be a panel discussion with audience participation.

The session will be held from 1:30 p.m.-5 p.m. in the Britannia Room of the Westin Hotel on Tuesday, June 23.

1:30 Introduction

1:35 **John A. Masters,** President, and **James K. Gray,** Executive Vice President, Canadian Hunter Exploration, Ltd.: "Goodbye Lone Eagles."

2:00 **M. B. "Duke" Rudman,** General Partner, and **James C. Trimble,** Vice President, The Rudman Partnership: "Buying Into Oil and Gas Prospects — The Art of the Deal."

2:30 **Hon. Roy M. Huffington,** former Chairman, Roy M. Huffington, Inc.: "Going International."

3:00 **Thomas A. Cunning,** President, Alberta Stock Exchange: "Oil and Gas Investing from the Perspective of the Capital Markets."

3:30 Panel Discussion

For further information contact the AAPG Convention Department, (918) 584-2555.

REMEMBRANCES

Emory V. Dedman, April 12, 1992.

Patrick N. (Pat) Glover, September 30, 1991.

Frank R. Hardin, February 13, 1992.

Clyde Earl Harrison, March 28, 1992.

Hillord Hinson, April 4, 1991.

Clarence David (Dave) Norman, October 22, 1991.

William E. (Bill) Todd-Brown, Sr., March 19, 1992.

OPINION

ENVIRONMENTAL VERSUS EXPLORATION AND PRODUCTION SPENDING

By William Feathergail Wilson
Consulting Geologist, Strata Environmental Services

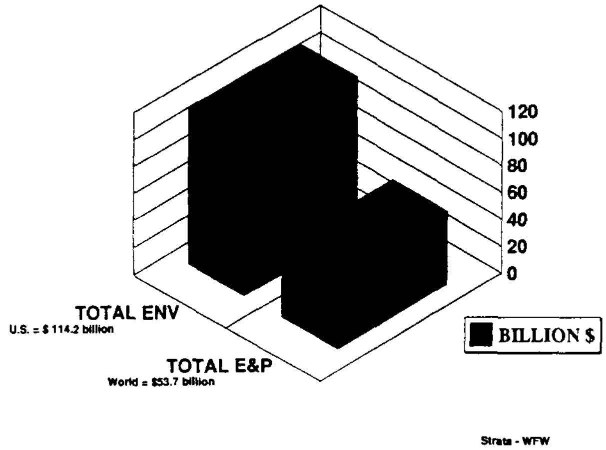
The cost of cleaning up the environment within the United States is enormous and increasing rapidly. Environmental costs dwarf comparable Exploration and Production spending. This situation offers both opportunity and deterrent to geologists in the E&P arena. The geological path to these new opportunities depends upon the flexibility and willingness to access a modicum of re-education. The most opportunity exists for those geologists who continually educate themselves throughout their career. Continual education is simply a **preventative maintenance program** to not allow technology and rapidly changing business climates to overwhelm experience.

The total U.S. Exploration and Production budget for 1992 is estimated at **$15.7 billion,** while the U.S. environmental spending is seven times that figure at **$114.2 billion.** The spending for ground water alone is **$46.8 billion.** The total worldwide E&P budget barely nudges out ground water at **$53.7 billion.** However, total U.S. 1992 environmental spending is estimated to be **$114.2 billion.** The following figures depict these relationships in a series of 3-D bar graphs.

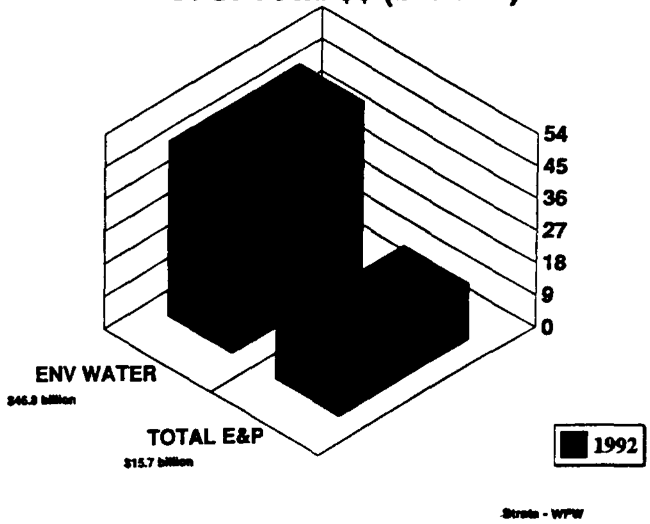
ENTITY	MEMBERS (millions)	REVENUE (millions)
Natl Wildlife Federation	5.1	$75.30
Greenpeace U.S.A.	2.3	$43.40
World Wildlife Fund	0.97	$48.60
Natl Audubon Society	0.6	$37.30
The Nature Conservancy	0.56	$168.60
Sierra Club	0.64	$37.30
Ducks Unlimited	0.508	$67.50
The Wilderness Society	0.35	$14.40
Environmental Defense Council	0.2	$17.00
Natural Resource Defense Council	0.16	$17.00
Totals	11.388	$526.40
American Petroleum Institute	0.000025	$65.50
AGA	0.00035	$53.40
IPAA	0.00053	$3.00
PESA	0.00002	$0.95
PBPA	0.0001	$0.14
IADC	0.0001	$2.10
WeCTOGA	0.000075	$0.13
NTOGA	0.0001	$0.18
TIPRO	0.0003	$0.77
NMOGA	0.000085	$0.00
Totals	0.001685	$126.16

Hydrogeologists deal with the complexities of ground water. They pick locations based upon facies architecture, flow regimes, water quality and many familiar factors to petroleum geologists. There are some differences and they mostly fall under the umbrella of mathematics and reservoir mechanics. Hydrogeologists share a percentage of the drilling "pie" from a base of at least **$46.8 billion,** while the

'92 E&P Versus Environment
Worldwide E&P Versus U.S. Environment Spending

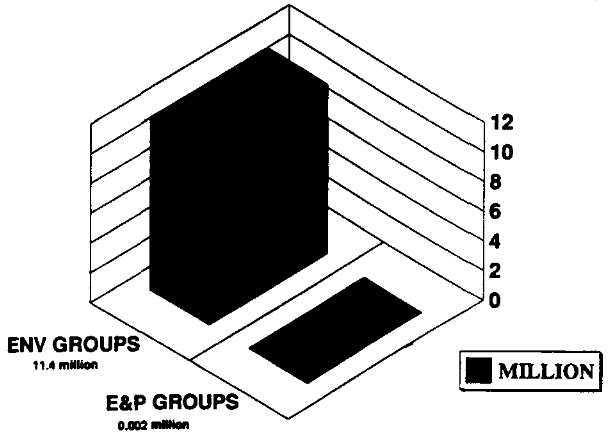


'92 E&P Versus Environmental Water
U. S. Total $$ (billions)

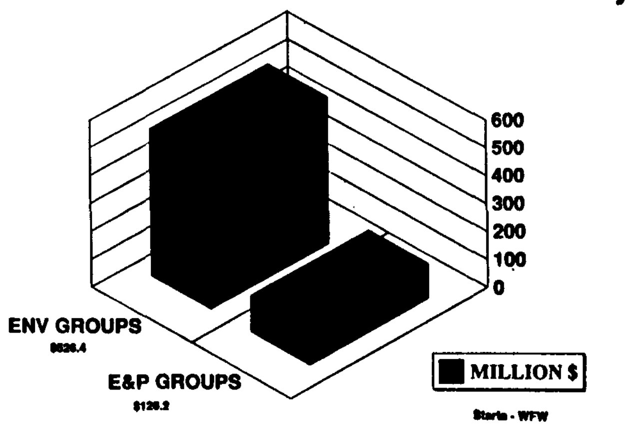


U.S. petroleum geologists can anticipate slicing their share out of a modest **$7.84 billion** drilling budget. Hydrogeologists have a six-fold advantage to access their portion of the **"water slice"**. Hydrogeologists or environmental geologists also work within other partitions of the environmental field, driven by statute and regulation. They participate in categories of waste clean up, including RCRA (Resource Conservation and Recovery Act), the Clean Water Act, the Clean Air Act, and the Safe Drinking Water Act. The Environmental Protection Agency estimates that

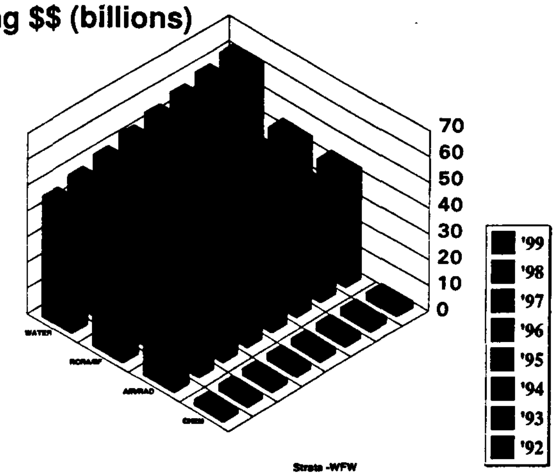
'91 Membership
Environmental Versus Petroleum Industry



'91 $$ ORGANIZATION REVENUES
Environmental Versus Petroleum Industry



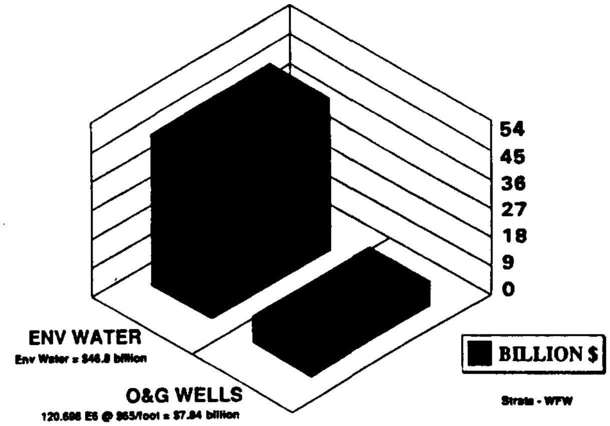
Environmental Spending $$ (billions)



water quality will receive the lion's share of environmental spending in the next few years.

The environmental industry has a large and powerful constituency with a political action membership of more than eleven million people with annual budgets that exceed **$500 million,** largely targeted toward legislation. The petroleum industry has a relatively small constituency with group

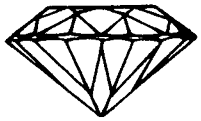
'92 Spending Comparison
Total $$ (billions) U.S.

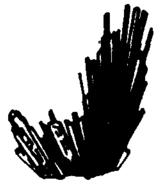


membership at far less than one-quarter million, concentrated in only four states. The petroleum political action organizations have five times less to spend than comparable environmental groups at **$126 million.** All of this begs the question..."Where are the future opportunities for the geological profession?"

The author presents a series of self explanatory graphs and one table that attempt to grapple with the opportunity question. The numbers and comparisons should be very surprising to petroleum geologists, who believe in the conventional myth that water is **not** something to "write home about".

Continued on page 35





HGS GUEST NIGHT
FRIDAY, JUNE 5, 1992

at

THE HOUSTON MUSEUM OF NATURAL SCIENCE

and

THE WORTHAM IMAX THEATRE

featuring

An Exclusive* HGS Showing of the Award Winning IMAX Film

"ANTARCTICA"**

with

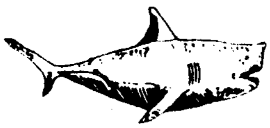
*Mexican Dinner Buffet Catered by Ninfa's***

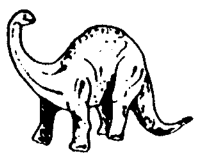
**Tentative Film and Caterer Selection

$ 25.00 PER PERSON

SPONSORED IN PART BY

Anadarko
Petroleum Corporation





6:00-7:00pm Museum Doors Open, Social & Browsing Hour with Cash Bars
Be Sure to See the Gem, Mineral, and Seashell Collections!

7:00-8:00pm Dining in Museum on Two Levels

8:15-8:45pm Awards Presentations in Museum

9:00-10:00pm "Antarctica" in IMAX Theatre

Reservations and Payment Required by Mailing Check to:
HGS Guest Night Event, 7171 Harwin, Suite 314, Houston, Texas 77036.
Call HGS at 785-6402 to confirm receipt of your check.
Send Your Check Soon , Only 400 Seats Available.
Refunds available thru April 1st, 1992.

NO SALES AT DOOR! ADMITTANCE BY NAME TAG ONLY!

***This film is being shipped to the Museum for our event only, and is not scheduled for any public showings in Houston.**

The Houston Museum of Natural Science is located in Hermann Park across from Miller Theatre at One Hermann Circle.

REGISTRATION FORM FOR HGS GUEST NIGHT EVENT
Enclose check payable to HOUSTON GEOLOGICAL SOCIETY.

NAME: ______________________ COMPANY: ______________________
WORK PHONE: ______________________ GUEST NAME: ______________________

HOUSTON GEOLOGICAL AUXILIARY

The Houston Geological Auxiliary is looking forward to an exciting year for 1992-1993. Lois Matuszak, First Vice President, is busy planning the events for the season, beginning in September and going through May. Since Game Day this March proved so popular, we are incorporating it in our program, so we will have a total of five events instead of four as in the past.

We would like to welcome all of our previous members and invite prospective members to join our organization. If your spouse is an HGS member in good standing or if you are a female geologist in good standing you are eligible to join the Auxiliary.

The purpose of the HGA is to encourage social interaction among its members and to assist the HGS in any manner they shall request, including, but not limited to, assisting the HGS office staff; helping at social functions and contributing to the HGS Scholarship fund.

To be included in our Year Book the annual dues of $15.00 should be paid by July 1. A check made payable to HGA should be sent to:

Mrs. George E. Gordon
HGS Membership Chairman
3110 Briar Court
Sugar Land, Texas 77478

We look forward to greeting our old members and getting acquainted with the new ones. If there are any questions about the HGA please call me at 468-3768.

GWINN LEWIS
President

YEARBOOK INFORMATION

(Last Name) (Your Name) (Spouse's Name)

Address ______________________

______________________ Zip________

Home Telephone ______________________

HGS Member's Company ______________________

Environmental Spending, cont. from page 33

REFERENCES

Carlin, A., Environmental Investments: The Cost of a Clean Environment, EPA-230-12-90-084, 1990.
Crandell, J. B., Lau, C. Y., Wilson, J. R., Janec, S. T., E&P Spending to Focus on International Areas, World Oil, pp. 43, February 1992.
Roper, J. C., Do You Believe in Miracles, Editorial, Southwest Oil World, pp. 6, February/March 1992.

PROSPECT LAMENT
or
RAPPERS ODE TO THE OIL PATCH
by Kenneth E. Nemeth

To the tune "I Want to Take You Higher"
by Sly and the Family Stone.

I'm Joe Bob Willie and...
I'll knock you silly.
My prospect's cool
It'll make you drool
SO BUY IT!

Chorus: Boom shaka-lacka lacka
Boom shaka-lacka lacka

I've got lots of sand
and lots of column.
Got porosity and perm
So don't look so solemn.

We got traps, we got oil
We got lots of gas.
My prospect is cool,
Don't let it pass.
SO BUY IT!

Chorus: Boom shaka-lacka lacka
Boom shaka-lacka lacka

You all buy my leases
It'll make me happy.
You'll get a well that pleases
That ain't no crappy

You bought my deal
And I got my money.
So let's get truckin'
And drill this thing, honey.
SO DRILL IT!

Chorus: Boom shaka-lacka lacka
Boom shaka-lacka lacka

Let's put that hole down
Make it turn to the right.
When we reach TD
It'll be a pretty sight.

We'll drill this well
And log it too.
Might even test it
Before we're through
SO DRILL IT!

Chorus: Boom shaka-lacka lacka
Boom shaka-lacka lacka

Now don't blame me
If it don't come in.
Say it's got somethin' to do
With the engineerin'.

Don't say I sold you
A pig in a poke.
'Cause I'm Joe Bob Willy
And I'll knock you silly.
My prospect's cool
It'll make you drool.

Chorus: Boom shaka-lacka lacka
Boom shaka-lacka lacka

BUSINESS OF GEOLOGY

3-D Seismic Technology Pays Off for Houston Independent: A Case Study*

by Joe B. Foster,
Newfield Exploration Co.
and Jay E. Valusek,
Landmark Graphics Corp.

Historically, only the large oil companies have had sufficient budgets and technical know-how to justify 3-D seismic surveys and computer-aided exploration (CAEX) workstations. But all that is changing. Not only is 3-D seismic data getting cheaper, but the costs of associated computing systems are coming down—providing smaller independents access to CAEX technology already tested and proven by the majors.

This article will show how and why one small operator, Newfield Exploration Company, has made a significant investment in 3-D seismic technology—and seen that investment paid off **even before drilling,** in a field written off as marginally economic by the previous operator.

Both in the Gulf of Mexico and in other mature U.S. basins, the major oil companies are actively engaged in disposition of "non-strategic" properties. These dispositions open up exciting, often unprecedented, possibilities to independents with sufficient foresight, low enough overhead, and the 3-D seismic advantage.

INVESTMENT IN 3-D SEISMIC TECHNOLOGY

Newfield is an example of a new breed of small, young independent exploration and production companies committed to high technology from the ground up. Its original business plan called for a two-fold focus: geographically, in the Gulf of Mexico; and technologically, on state-of-the-art seismic, with an emphasis on 3-D data. Since Newfield was founded in late 1988, the company has purchased over 30,000 miles of seismic data in the central Gulf, at a cost of well over $3 million. And as early as 1989, it acquired a Landmark interactive workstation to help interpret that data.

The main reason Newfield made a more substantial investment in 3-D seismic technology than most other comparably-sized independents was to differentiate itself, and obtain a strong competitive advantage. Through technology, the company sought to accomplish three goals: to create business opportunities, to reduce drilling risk, and to boost productivity.

First, because Newfield seeks farm-ins and reserve acquisitions in the Gulf, it hoped that the ability to efficiently work 3-D data would open up opportunities to acquire options to drill on acreage held by the majors, in exchange for high quality interpretation of their 3-D seismic. Having an interactive seismic workstation has, in fact, resulted in several such deals that would not otherwise have been made.

Second, previous experience at Tenneco Oil (where most of Newfield's 16 geoscientists and engineers had been employed until the sale of Tenneco's oil and gas assets in 1988) had proven that 3-D seismic was simply more effective than 2-D in reducing drilling risk. With 2-D data, in many cases, the reflections do not come from directly below the lines or shotpoints on the map. But because 3-D seismic takes such a closely-spaced sampling of the earth and employs special processing techniques, the location of reflections—hence, of small and elusive targets—is much more definitive. As a result, 3-D seismic can produce a true three-dimensional image of the subsurface—a solid "cube" of data—more like a hologram than a two-dimensional "snapshot."

Third, because 3-D seismic data is typically more detailed and voluminous than 2-D, the only timely and cost-effective way to interpret it is with an interactive workstation. Trying to interpret a 3-D survey by hand would be like mowing the lawn with a pair of clippers. Besides, the workstation provides analytical techniques not possible in the paper world. In addition to giving seismic interpreters more confidence in their final recommendations, it also enables managers, partners, and investors to **see and understand** the resulting geological interpretations with remarkable clarity.

As shown in the following case study, the payoff to an independent operator can be significant.

ACQUISITION OF THE EUGENE ISLAND BLOCK

In May 1990, Newfield acquired Eugene Island block 172, offshore Louisiana—a "non-strategic" property offered for sale by the one of the majors. At the time of the sale, Newfield estimated reserves at 7 billion cubic feet (BCF) of natural gas proven, with perhaps 12 to 15 BCF probable. But probable reserves were so uncertain they could not be considered in the bid for the lease. The property was acquired for about $5 million. Production at the time of acquisition was approximately 3 million cubic feet of gas per day (MMCF/D), and two of the four producing wells were shut in due to tubing leaks.

Newfield's geoscientists and engineers initially evaluated Eugene Island 172 using well log and production information only. But they knew that the previous operator had acquired a 3-D seismic survey of the field, and believed that it had not been thoroughly interpreted. They suspected that if they could reevaluate the 3-D survey on their interactive workstation, they might discover additional proven reserves beyond 7 BCF. That, in fact, is what happened.

First, however, upon acquiring the block Newfield commenced a $2 million workover program to reestablish

* *Reprinted with permission from* American Oil and Gas Reporter, *Feb. 1992*

production from the two shut-in wells. As a result, in a short period of time, daily production jumped from 3 to 18 MMCF/D, and 450 barrels of condensate.

REINTERPRETATION OF THE SUBSURFACE

A salt dome underlies Eugene Island block 172. Current gas production comes from multiple reservoirs, the deepest of which is at about 14,000 feet, along the northern flank of the dome. Four wells had been drilled from a central platform, in addition to 12 other wells drilled several decades ago during initial exploration and development. Newfield had only 7 data points at the target depth prior to obtaining the 3-D seismic survey. Complex faulting and depositional patterns associated with salt emplacement made it difficult to determine reservoir geometry with confidence, especially with such limited control information.

The 3-D survey, which Newfield acquired along with the lease, covered all of Eugene Island 172, and portions of the eight surrounding blocks. It consisted of 326 lines, shot from north to south; each line was about six miles in length. Once 3-D seismic data was loaded onto the workstation and analyzed in detail, the original subsurface interpretation was altered in two significant ways. First, 3-D seismic imaging confirmed a suspected well log miscorrelation, and thereby solved a well performance problem. And second, the fault pattern turned out to be considerably different than either the previous operator or Newfield had thought.

The ability to slice through the 3-D data "cube" both vertically and horizontally, and to view it in three dimensions on the computer screen, proved vital to the success of reinterpretation. One technique in particular—creation of an "arbitrary line" (a vertical seismic section generated at any desired azimuth through the data volume)—helped explain why the takepoint in a structurally-higher well near the salt apparently wasn't draining reserves seen in wells downdip. Newfield's geoscientists knew there was a problem with the interpretation, but could not determine exactly what it was until they created an arbitrary line that ran through several key wells (Fig. 1).

Once this was done, it was evident that the target sand had been miscorrelated with a completely **different** sand updip. 3-D seismic revealed a significant stratigraphic thinning of the interval immediately above the pay sand, from the off-structure wells toward the salt dome. This stratigraphic thinning had not been accounted for in the earlier interpretation. Clearly, the updip well had been producing from a somewhat deeper reservoir, and the main pay sand had not been produced at all. This became an important factor in revising the proven reserve calculations.

Another interactive 3-D seismic workstation technique—the "time slice" (or **horizontal** seismic section generated at any desired level within the 3-D data volume)—helped resolve complex fault patterns. By creating a series of time slices at regular intervals (Fig. 2), it was possible to dramatically improve Newfield's understanding of the spatial position and migration with depth of major fault planes radiating off the salt dome. At about 14,000 feet, pay sands in the target interval produce from a number of different fault blocks. The revised fault interpretation allowed Newfield's geoscientists to determine which reservoirs had been produced, to identify remaining proven reserves, and to pinpoint additional drilling opportunities.

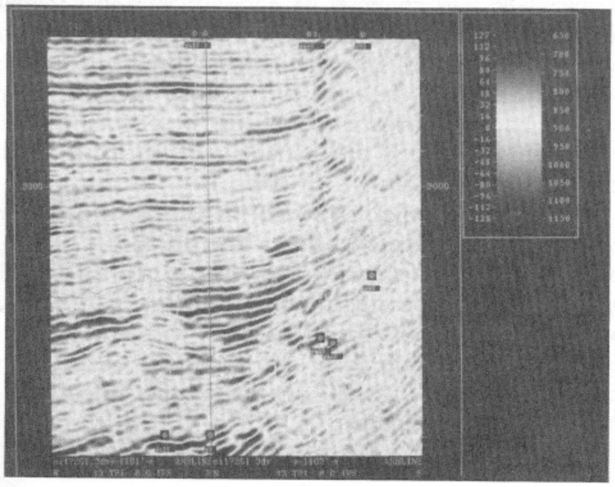


Figure 1. Arbitrary seismic sections like this one allowed Newfield to correct a miscorrelation between wells offstructure (left) and updip producing wells on the flank of the salt dome (right). The main target sands are indicated by strong amplitudes near the center.

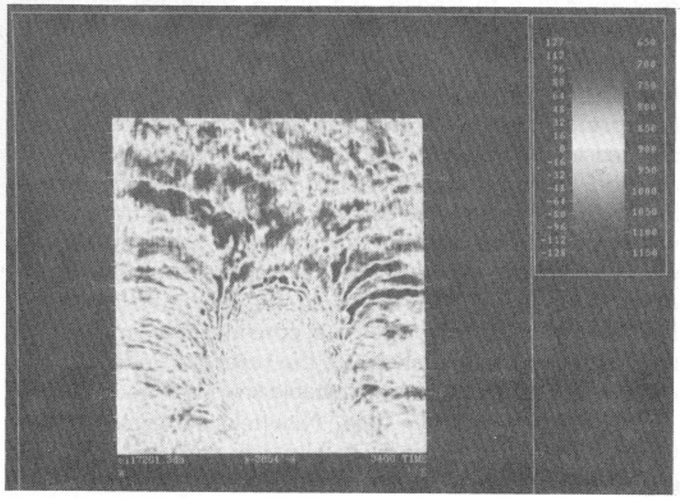


Figure 2. "Time slices," or horizontal seismic sections through the 3-D data cube, helped Newfield geoscientists unravel complex faulting patterns associated with salt emplacement. Small circles indicate faults or well locations. Two-way travel time is at 3.4 seconds.

MONEY IN THE BANK

As a result of these and other interactive analyses of 3-D seismic data, it became possible to demonstrate with a high degree of certainty that there were far more proven reserves of natural gas than 7 BCF on Eugene Island 172. Instead, there were over 20 BCF—nearly three times the original estimate.

Once Newfield's reinterpretation was complete, outside reserve auditors were brought in to look it over. Two things convinced them the higher proven reserve figures were correct. First, the ability to graphically visualize both faults and stratigraphic details on the workstation—and to display three-dimensional perspective views of sedimentary horizons penetrated by the salt—made it extremely easy to show the independent reserve engineers exactly how and why Newfield had changed its geophysical and geological interpretations. Second, production rates since Newfield had worked over the shut-in wells corroborated much higher reserves than originally estimated. Within one year's time, Newfield had produced enough gas to recover its initial investment in the block, and continued producing at rates in excess of 10 MMCF/D.

By tripling Newfield's proven reserves in the field, the company was immediately able to **borrow more money**—even before drilling a single well—which, of course, is vital to any independent operator's future. Without 3-D seismic it may have been impossible to establish with any degree of confidence the stratigraphy and structure of pay zones between the wells, which was absolutely necessary to increase the reserve figures.

OTHER USES OF 3-D SEISMIC TECHNOLOGY

On Eugene Island 172, Newfield used 3-D seismic and the interactive workstation both to detect the presence of faults and to revise the original fault pattern, to solve a well log correlation problem, to increase proven reserve estimates, and to effectively present the subsurface reinterpretation to lenders and obtain additional capital for business ventures.

Newfield has utilized 3-D seismic technology in a number of other projects as well. As noted earlier, interpretation of 3-D data for major oil companies has resulted in an option to drill on certain offshore acreage. In addition, speculative 3-D seismic data has helped precisely locate development wells and resolve unitization negotiations with an adjoining operator. In the past, geophysics would never even have entered into such discussions. But in this case, by sharing the results of its 3-D interpretation, Newfield was able to alleviate considerable uncertainty regarding the size and shape of the reservoir under dispute, and reach agreement on an equitable sharing ratio.

Finally, in another field, Newfield actually used the workstation not to interpret geophysical data, but well data. In particular, there were a number of well logs with so many fault cuts that the geologist was finding it nearly impossible to reliably correlate all those fault cuts from one well to the next. As a result, hundreds of possible fault plane interpretations might have been made. But loading the data onto the workstation allowed him to test out many different hypotheses very rapidly, and to select the one that made the most sense geologically.

As one Newfield interpreter put it,"The workstation reduces the cost of being wrong." With paper mapping, even when a geoscientist is not completely comfortable with an interperation, it is often so onerous to change it that he just leaves it alone. But the workstation allows him to vary the interpretation significantly—as many times as necessary to get it right. As another interpreter once said, "Ultimately, the interactive workstation is a decision-making tool. If the interpreter makes the correct decisions in his analysis of the data, management can make the correct decisions whether to drill or not to drill."

CONCLUSION

More independents in the U.S. today are beginning to turn to 3-D seismic and computer-aided exploration technology to give them the competitive edge they need to succeed. Not only in mature offshore areas, but onshore as well, small and mid-size independents are finding that 3-D seismic is no longer a luxury, especially as lower cost 3-D data—including "postage stamp," group shoot, and speculative 3-D surveys—become more widely available.

Independents can keep their heads above water either by biting the bullet and purchasing a workstation themselves, as Newfield did, or by contracting the services of E&P consultants experienced in 3-D seismic technology. Either way, the benefits now outweigh the drawbacks. And small operators that make the investment today stand a better chance of coming out on top in the tough times ahead.

About the authors

Joe B. Foster is Chairman and CEO of Newfield Exploration Co. Prior to founding Newfield in 1988, he served as Executive Vice President and director of Tenneco, Inc., and as Chairman of Tenneco Oil Co. He joined Tenneco in 1957 as a petroleum engineer, with a degree from Texas A&M University. He served in various engineering, exploration and executive capacities during his 30 year career with Tenneco. Foster is a member of the National Petroleum Council and serves on the American Petroleum Institute's Committees on Exploration and Production. He also serves on the Board of Directors of Baker Hughes, Inc. and Valero Energy Corporation.

Jay E. Valusek is Senior Writer, Corporate Communications, with Landmark Graphics Corporation. He has published dozens of articles on computer-aided exploration trends and successes around the world. Prior to joining Landmark in 1988, he was employed as a production geologist with Pennzoil Company's U.S. Offshore Division. Valusek graduated *magna cum laude* from Wichita State University, and earned his M.S in geology from the Colorado School of Mines. He is a member of HGS, AAPG, and SEG.

Houston Geological Society 1923

FEATURE

FOR YOUR INFORMATION: A CREATIONIST BLUNDER TABLE

By Ronnie J. Hastings

Despite several years of critical research of claims made by creationists working along the Paluxy River near Glen Rose, Texas, and despite several publications exposing the scientific bankruptcy of these claims, occasional uncritical references to the claims still arise. In one sense, this is as surprising as present-day references to cold fusion being uncritical. But in another sense, one which takes into account public credulity and lack of information concerning scientific-sounding claims, perhaps it is not so surprising. Barnum's "There's a sucker born every minute" unfortunately is sometimes applicable in cases where "science" is being hawked.

Creationist "mantrack" and "mantooth" claims from the Paluxy are unique among the myriad of anti-evolutionism that marks creationism in all its forms, in that the evidence is concrete and, therefore, scientifically investigatable. Early claims met some skepticism among creationists themselves, but their perpetuation, leading to growing effects in public opinion and public education, induced outside investigation. Beginning as early as 1980, skeptical scientific scrutiny found the claims without evidence; the hallmarks of pseudoscience were evident from the outset. The claimants became almost as interesting a study as the claims themselves, complete with bogus science degrees and deliberate deception.

Though most of the broad spectrum of issues concerning creation/evolution have been covered during the years of exposing the Paluxy claims, the claims basically constitute and out-of-order fossil argument trying to imply that the geological column is wrong, and, therefore, the whole evolutionary perspective is also wrong. No legitimate out-of-order fossil has ever been found by the Paluxy creationists, though most of them still want to argue the point.

To conveniently meet any resuscitation of Paluxy creationist claims, a "Blunder Table" has been compiled and is given below. If more detail is needed, the references cited should more than suffice. More often than not, those in the public ignorant of the expose' of the claims simply have not seen these references. It is anticipated that Kuban (1991) will be a definitive overall history of the Paluxy creationist claims for those who like a "blow-by-blow" account of the "mantrack and mantooth sagas."

Interestingly, unexpected insights into dinosaur locomotion and behavior cropped up in the course of investigating the Paluxy "mantrack" claims. Many of the alleged "mantracks" were genuine prints made by dinosaurs walking in an unusual manner: plantigrade, down upon their foot bones (metatarsals) as humans do rather than the usual digitigrade manner, upon their toes. In addition, preservation of tracks via erosion-resistant infilling material became a focus of the research, for many "mantracks" revealed themselves saurian, even to committed creationist "mantrackers," through this phenomenon. For my colleague Glen Kuban and me to experience the pursuit of "mantrack" claims turning into new foci for dinosaur track research was pure scientific delight.

Though the Paluxy creationists are but a minority in the ranks of creationism, they have "made a lot of noise" over the years, making themselves an enormous embarrassment to the rest of the creationist movement; the Paluxy creationists are to "scientific" creationism what Saddam Hussein is to diplomacy. Hopefully, we will see further criticisms of Paluxy claims from creationists themselves. Too many innocent and well-meaning people have been conned by a pseudoscientific Paluxy claim wrapped in Scripture and

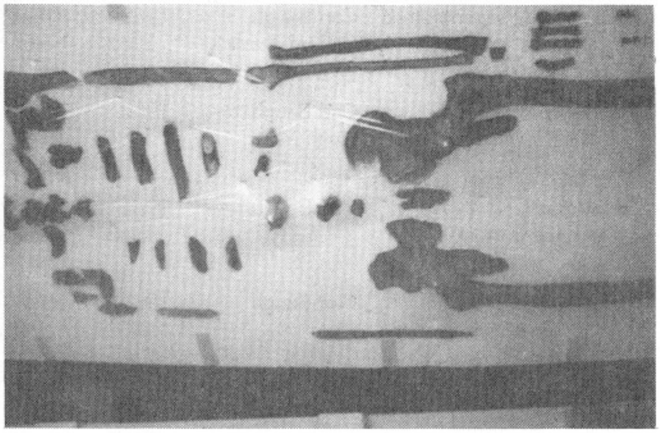


Fig. 1 - One of two human skeletons known as "Moab Man" found near Moab, UT in an intrusive burial site (described as a "cave-in" by the finder). Despite the recent dating of the bones (200-300 years), many creationists, most notably Carl Baugh, who bought one of the skeletons for his Creation Evidences Museum, maintain the bones are the same age as the Mesozoic rock at the burial site. (Photo by K. Person)

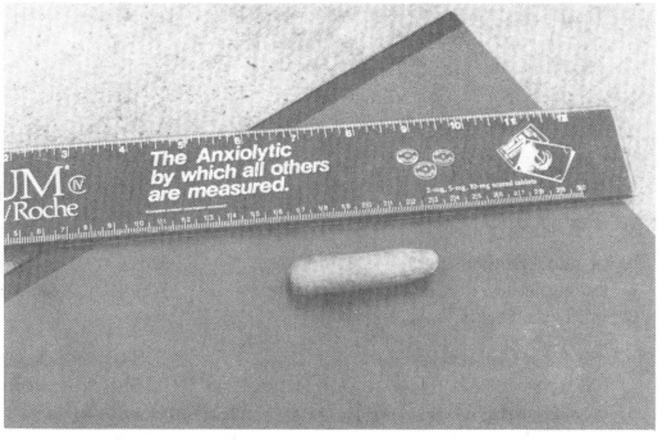


Figure 2. - Iron oxide nodule described by Carl Baugh as a "fossilized human finger." Deemed also as "female" due to its "delicate" proportions. (Photo by K. Person)

PALUXY CREATIONIST TABLE OF BLUNDERS

The following is a table of the major claims made by creationists associated with phenomena found along the Paluxy River near Glen Rose, Texas. Though not exhaustive, it surely is indicative of how creationist "mantrack" and "mantooth" enthusiasts have, through their pseudoscientific activities, harmed the creationist movement not only in Texas but nationwide. (After Godfrey & Cole, 1986, "Blunder in Their Footsteps," Natural History, 8/86, p 8.)

Claim	Major Claimant(s)	Date(s)	Reality	Investigators	References
"Mantracks" on Park Ledge in Dino Valley Cecil State Park	Stan Taylor Cecil Dougherty	1970s	Preferential Erosion Patterns	Milne Schafersman Kuban	Taylor (1970), Dougherty (1971), Milne and Schafersman (1983), Godfrey and Cole (1986), Kuban (1991)
Burdick "mantracks"	Clifford Burdick Carl Baugh Don Patton	1930s-1990s	Carved fakes with gross anatomical errors & chisel marks (subsurface features in sectioned carving are fossils, not stress marks)	Milne Schafersman Kuban, Godfrey Hastings Wilkerson	Godfrey and Cole (1986), Kuban (1991), Burdick (1950)
Caldwell "mantrack" (now at Columbia Union College)	Billy Caldwell Carl Baugh Don Patton	1930s-1980s	Clearly a carving; never seen in river bed; sectioned to show it a carving	Kuban Godfrey, Cole	Godfrey and Cole (1986), Kuban (1991)
"Mantracks" & "saber-toothed cat tracks" on Baugh-McFall ledge (a)	Carl Baugh Clifford Burdick Hugh Miller	1982-1985	Trace fossils (worn & crustacean burrows)	Godfrey, Cole Schafersman Kuban, Hastings	Baugh (1987), Cole and Godfrey (1985), Hastings (1988)
"Mantracks" on Baugh-McFall ledge (b)	Carl Baugh Hugh Miller	1982-1986	Isolated markings alongside dinosaur tracks; perhaps made by walking dinosaur	Godfrey, Cole Schafersman Kuban, Hastings	Baugh (1987), Cole and Godfrey (1985), Hastings (1986, 1988)
"Ordovician" hammer-in-stone	Carl Baugh	1982-1988	Concretion around a miner's mallet	Cole Hastings	Godfrey and Cole (1986), Baugh (1987), Cole and Godfrey (1985)
"Moab Man" bones in Mesozoic rock	Carl Baugh	1983-1990s	Intrusive recent (200-300 yrs.) burial (apparent cave-in)	Hastings Kuban	Cole and Godfrey (1985), Hastings (1986, 1987a, 1988)
"Fossilized human finger"	Carl Baugh	1988-1990s	Cylindrical iron oxide nodule	Hastings	Hastings (1991)
"Fossilized Cretaceous human tooth"	Carl Baugh Don Patton	1987-1989	Fossilized fish incisor	Hastings Kuban	Hastings (1987b, 1987c, 1991)
"Fossilized primate skulls"	Carl Baugh Hugh Miller	1984	Weathered limestone nodules	Schadewald Zindler, Sillman	Schadewald (1984)
Taylor Site "Mantracks" (a) (Taylor Trail, Giant Run, Turnage Trail, Ryals Trail)	Stan Taylor Hilton Hinderliter Paul Taylor John Morris Wilbur Fields John DeVilbiss	1968-1985	Elongate dinosaur tracks made by plantigrade locomotion	Hastings Kuban	Taylor (1970), Milne and Schafersman (1983), Godfrey and Cole (1986), Kuban (1986a, 1986b, 1991), Baugh (1987), Cole and Godfrey (1985), Hastings (1986, 1987a, 1987b, 1987c, 1987d, 1988), Hinderliter (1984), Taylor (1985), Morris (1980)
Taylor Site "Mantracks" (b) (Beierle Trail)	Fred Beierle John Morris	1978-1988	Elongate dinosaur tracks made by plantigrade locomotion	Kuban Hastings	Kuban (1991), Morris (1980)
Taylor Site "Mantracks" (c) (human tracks inside dino tracks on Taylor Trail)	Carl Baugh Don Patton	1987-1990s	Erosion features within dinosaur tracks making up Taylor Trail	Kuban Hastings	Kuban (1989, 1991)
Trilobitr from Cretaceous Paluxy river bed	Carl Baugh Don Patton	1984-1988	Silurian trilobite fossil from Illinois lost or salted at the Paluxy	Hastings Kuban	Kuban (1991), Baugh (1987), Hastings (1986, 1987, 1991), Pewe (1985)
"Trilobite" found close to human tooth" find	Carl Baugh	1987	Fossilized row of fish grinding teeth	Hastings	Hastings (1991)

flavored with anti-evolutionism. Just a little self-respecting scientific scrutiny would have prevented some very painful and embarrassing intellectual indigestion.

If nothing else, the Paluxy claims are for the scientific community still another opportunity to talk about what science is and how it works. They also provide a vehicle to remind us all of the historical development of the science we employ today, as well as to review the philosophical foundations of modern science. Scientists, teachers, and laypersons alike must constantly promote the advantages of using scientific methodology, especially skeptical scrutiny. Science education is a perpetual task and responsibility.

REFERENCES

Baugh, Carl E., 1987, **Dinosaur. Evidence that Dinosaurs and Men Walked Together,** Promise Publishing Inc., Orange, CA.

Burdick, C. L., 1950, "When GIANTS Roamed the Earth: Their Fossil Footprints Still Visible!" **Signs of the Times,** July 25, pp 6, 9.

Cole, John R. & Laurie R. Godfrey, eds., 1985, The Paluxy River Mystery — Solved. **Creation/Evolution,** XV, 5 (1).

Dougherty, C., 1971, **Valley of the Giants**. First Ed., Bennett Printing Co., Cleburne, TX.

Godfrey, Laurie R., & John R. Cole, 1986, "Blunder in Their Footsteps." **Natural History,** 8/86, August, pp 4-12.

Hastings, Ronnie J., 1986, "Tracking Those Incredible Creationists — The Trail Continues. **Creation/Evolution,** XVII, 6(1): pp 19-27.

Hastings, Ronnie J., 1987a., "Tracking Those Incredible Creationists — The Trail Goes On. **Creation/Evolution,** XXI, 7(2): pp 30-42.

Hastings, Ronnie J., 1987b, "Glen Rose Man—Creationists' 'Nebraska Man'?" **C/E Newsletter,** 7(4): pp 15-16.

Hastings, Ronnie J., 1987c, "Creationists' Tooth Claims Evolve Into a New 'Fish Story'." **C/E Newsletter,** 7(5): pp 18-20.

Hastings, Ronnie J., 1987d, "New Observations on Paluxy Tracks Confirm Their Dinosaurian Origin." **Journal of Geological Education,** 35(1): pp 4-15.

Hastings, Ronnie J., 1988, "The Rise and Fall of the Paluxy Mantracks," **Perspectives on Science and Christian Faith,** American Scientific Affiliation, 40(3): pp 144-155.

Hastings, Ronnie J., 1991, "A Tale of Two Teeth." **Creation/Evolution,** in publication.

Hinderliter, Hilton, 1984, "Observations on the Paluxy evidences." **Bible-Science Newsletter,** 22(12): p 5.

Kuban, Glen J., 1986a, "The Taylor Site 'man tracks' and Review of ICR Impact article 151." **Origins Research,** 9(1), Spring/Summer, pp 1, 7-13.

Kuban, Glen J., 1986b, "A Summary of the Taylor Site Evidence." **Creation/Evolution,** XVII, 6(1): pp 10-18.

Kuban, Glen J., 1989, "Retracking the Taylor Trail Tracks." **NCSE Reports,** 9(4).

Kuban, Glen J., 1991, **The Texas "Man Track" Controversy,** Published by Glen Kuban, P.O. Box 33232, North Royalton, OH, 44133, in preparation.

Milne, David H. & Steven D. Schafersman, 1983, "Dinosaur Tracks, Erosion Marks, and Midnight Chisel Work (But No Human Footprints) in Cretaceous Limestone of the Paluxy River Bed, Texas." **Journal of Geological Education,** Vol. 32, pp 111-123.

Morris, John D., 1980, **Tracking Those Incredible Dinosaurs...& the People Who Knew Them.** (Third Printing, Creation-Life Publishers, San Diego, CA.

Pewe, Troy L., 1985, "Prize for Trilobite in Cretaceous Not Yet Earned." Letter in **C/E Newsletter,** January/February, 5(1): p 15.

Schadewald, Robert, 1984, "Bible Science Conference: Emphasis on Geocentricity." News and Comments, **The Skeptical Inquirer,** 9(2), Winter 84-85, pp 111-113.

Taylor, Paul, 1985, "Notice Regarding the Motion Picture 'Footprints in Stone'," Form N-6, Films for Christ Assn., Mesa, AZ, December 4, revised December 5.

Taylor, Stanley E., 1970, **Footprints in Stone.** (Film), Films for Christ (Eden Films), Elwood, IL, (now Mesa, AZ).

RONNIE J. HASTINGS—Biographical Information

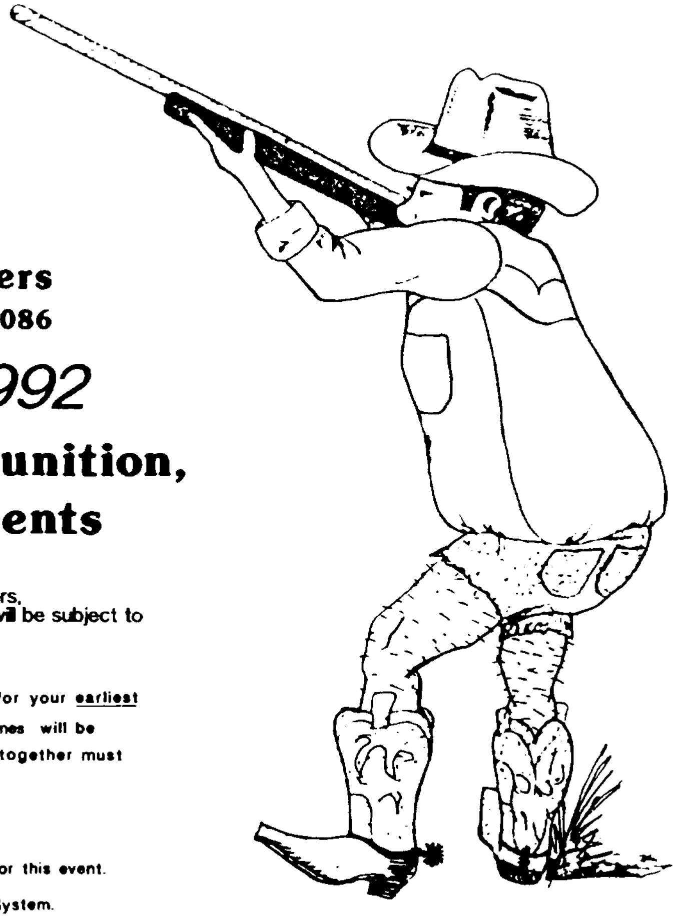
Ronnie J. Hastings earned a Ph.D. in physics from Texas A&M University. After a brief period as an adjutant professor at the University of Texas at Austin, he came into secondary school public education as an instructor of physics and advanced math at Waxahachie High School, where he has taught for the last eighteen years. Living only some sixty miles from Glen Rose, TX, he became the leading "local" critical investigator of creationist claims along the Paluxy River near Glen Rose. Motivated by his love of dinosaurs and the adverse effects of creationist influences in public school science education, Ronnie became an unofficial guide to dinosaur track sites along the Paluxy and a "watchdog" of creationist activities there. He is the one scientific investigator common to all professional investigations into Paluxy creationist claims since 1982. His slide shows on dinosaur tracks and creationist claims have been shown to a variety of interested groups.

Ronnie is a director for the National Center for Science Education, the national center for creationist-watching Committees of Correspondence in each state. He has served as a past president of the Texas Section of the National Association of Geology Teachers and is a member of The American Association of Physics Teachers and the American Association for the Advancement of Science. He is also a co-founder of North Texas Skeptics, an affiliate of CSICOP, the Committee for the Scientific Investigation of Claims of the Paranormal.

Houston Geological Society

10th Annual

Skeet Shoot



American Shooting Centers
16500 Westheimer Pkwy 556-8086

Saturday, June 27, 1992

$45 Includes 50 Targets, Ammunition, Door Prizes, and Refreshments

We are limited by time and field availability to approximately 200 shooters, so please REGISTER EARLY. Registrations received after Friday, June, 19 will be subject to an additional $10.00 late entry fee.

We will try to stay on schedule, rain or shine, so please register for your earliest convenient start time, be on time, and shoot your rounds quickly. Start times will be assigned on a first-come, first-served basis. Shooters who wish to squad together must mail their registrations together.

12 and 20 gauge ammunition will be provided; you must use this ammunition for this event.

NSSA and ASC safety and scoring rules apply: Modified Lewis Class Scoring System.

ENTRY FORM:

Name: ____________ **Tel.: (Res.)** ____________ **(Off.)** ____________

Address: ____________ **Company:** ____________

Guests: 1) ________ **2)** ________ **3)** ________ **4)** ________

Preferred starting time: (circle one) 7:00 8:00 9:00 10:00 11:00 12:00

Number of shooters $45 each: ____________ **Check One:** ☐ 12 gauge ☐ 20 gauge

Disclaimer:

I acknowledge that neither the Houston Geological Society nor the American Shooting Centers will be held responsible for injury or accidents during this event.

Member: ____________ **Guest:** ____________

Mail registration and check to:

Houston Geological Society
7171 Harwin Ste. 314
Houston, Texas 77036-2190

(Make checks payable to HGS Entertainment Fund, and remit with registration)

JUNE CALENDAR of EVENTS 1992

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
	1 AAPG School, Lake & Wardlaw, Marriott Greenspoint, June 1-3	2	3	4	5 HGS GUEST NIGHT DINNER "Antarctica" Wortham IMAX Houston Gem & Mineral Show Brown Convention Center, June 5-7	6
7	8	9	10 HGS ENVIR/ENG Committee Meeting Italian Mkt. & Cafe	11	12	13
14	15 HGS INT'L EXPL DINNER MEETING Bob Goldhammer Post Oak Dbltree	16	17	18	19	20
21	22 AAPG/SEPM/EMD Annual Meeting, Calgary, June 21-24	23	24	25 SIPES Luncheon Hank Gruy Houston Club	26	27 HGS 10TH ANNUAL SKEET SHOOT American Shooting Center
28	29	30				

GEO-EVENTS

MEETINGS

IN HOUSTON

HGS Guest Night Dinner, Museum of Natural History, Wortham IMAX Theater, "Antarctica", 6:00-10:00 p.m., June 5.

Houston Gem and Mineral Society 39th Annual Show, George R. Brown Convention Center, 10:00 a.m.-8:00 p.m., June 5 & 6 and 11:00 a.m.-6:00 p.m., June 7.

HGS Environmental/Engineering Geology Committee Meeting, Italian Market, 2615 Ella Blvd., 6:00 p.m., June 10.

HGS International Dinner Meeting, Bob Goldhammer, "Depositional Cycles, Composite Sea Level Changes, Cycle Stacking Patterns, and the Hierachy of Stratigraphic Forcing: An Example from the Middle Triassic Latemar of the Dolomites (N. Italy)", Post Oak Doubletree Inn, 5:30 p.m., June 15.

SIPES Luncheon, Hank Gruy, "Unusual Oil & Gas Fields", Houston Club, 11:30 a.m., June 25.

AROUND THE COUNTRY

SPWLA Annual Meeting, Oklahoma City, June 14-17.

AAPG/SEPM/EMD Annual Meeting, Calgary, Alberta, June 21-24.

SCHOOLS AND FIELD TRIPS

AAPG School, L. W. Lake and N. C. Wardlaw, "How the Rock and Reservoir Properties Determine Oil Recovery", Marriott Greenspoint, June 1-3.

OTHER EVENTS

HGS 10th Annual Skeet Shoot, American Shooting Center, 16500 Westheimer Parkway, June 27.

NOTE:

July Events:

SEG Short Courses, "Seismic Data Acquisition and Quality Control", July 13-14. "Field Acquisition for Exploration Objectives", July 15-16.

SIPES Luncheon, Carl Norman, "Houston Environmental Geology", Houston Club, 11:30 a.m., July 23.

August Events:

AAPG International Conference and Exhibition, Sidney Conference Center, Sidney Australia, Aug. 2-5.

SEPM Theme Meeting, "Mesozoic of the Western Interior", Ft. Collins, Colo., Aug. 17-19.

HGS Astroworld Days, Aug. 24-25.

COMMITTEE NEWS

1992 HGS TENNIS TOURNAMENT RESULTS

CHAMPIONSHIP

MEN'S (A)	MEN'S (B)
First Place	
Mike Walker Petroleum Testing Service	Khalid Razvi Examinoil
Mark Rose Richardson Seismic	John Adamick TGS
Second Place	
Ross Davis Davis Brothers	Jim Enyeart Geo. Consultant
Bill Hitze	Pat Shannon Shannon Exploration
Third Place	
Steve Allen Consultant	Don Cowden Sovereign Exploration
William Rabson Western Geophysical	Larry Jones Spartan Petroleum

The 1992 HGS Tennis Tournament was held at the Westside Tennis Club. Each division played a round robin consisting of six different partner pairings. Based on the percentage of games won, winners were chosen. Special thanks to the tournament committee for an excellent tournament: Arrowgraphics, Cindy Epps, Bill Howell, Ken Nemeth, Don Scherer (photography), Bill Scott of Petro-log (tennis balls) and Mike Walker.

First Place Men's A: Mike Walker and Mark Rose.

HGS Tennis Tournament

First Place Men's B: Khalid Razvi and John Adamick

GSH/HGS 1992 BASS TOURNAMENT 232 POUNDS CAUGHT!

The fourth annual tournament was a great success. Despite Mother Nature's cold front, rain, and shifting winds, 27 teams participated in this year's event (10 more than last year!). Boats were deluged with waves and rain on Saturday, but better weather was on hand Sunday.

We would like to congratulate the prize winners: In the **Team Total Weight** category, 1st Place was won by Bob Baker and Earl Taylor (33.95 lbs.), 2nd Place went to Jerry Cooley and Newt Feldman (29.35 lbs.) and 3rd Place was won by Don and Jerry Hayes (22.6 lbs.). Way to go teams!!

In the **Big Bass** category, 1st Place was won by Bill "Lunker" Rieniets with a 5.5 pounder, 2nd Place went to Harold "Catfish" Landers with a 4.8 pounder and the 3rd Place winner was Keith Chandleur with a 4.6 pounder.

In the **Live Bait** category, 1st Place for the Largest Crappie went to Brian "the Perch" Kimmel and 1st Place for the Largest Bream was won by Joe "Bluegill" Alcamo.

Thank you all for registering early to help Bill Roach, my Co-Chairman, and me plan the event in a timely manner.

Special thanks goes to our Sponsors for helping to make this event the success it was:

Ashland Exploration, Inc. .... Trophies
Diversified Well Logging .... Door Prizes
Geophysical Pursuit .... Mementos
Geosignal .... Door Prize
Halliburton Geophysical Services .... Grand Prize
Halliburton Logging Services .... Refreshments
Lone Star Seismic .... Door Prize/Co-Chairman
Seismic Resources .... Door Prize
Stratigraphic, Inc. .... Door Prizes
Welco, Inc. .... Door Prizes

Thank You!

JOE ALCAMO, Chairman
BILL ROACH, Co-Chairman

HOUSTON GEOLOGICAL SOCIETY PERSONNEL PLACEMENT COMMITTEE

NEW - The HGS Jobs Hotline (713/785-9729) has been established to help unemployed or underemployed members find employment.

HOW THE JOBS HOTLINE WORKS

Individuals interested in learning what job opportunities exist should call the dedicated telephone number to listen to a pre-recorded message listing the experience and expertise that is being requested by the prospective employer. If the caller is qualified and interested in the position, he or she should fax their resume to the Placement Committee at (713) 367-0116 within seven (7) days from when the job listing was placed in the system. The fax number as well as the seven (7) day time frame, will be provided in the pre-recorded message.)

WHY SHOULD MEMBERS DO THIS?

The Placement Committee has the generalized resumes of members on file. These resumes are sent to prospective employers upon request. Recently prospective employers have been very specific concerning the experience and expertise that they require. The resumes that the Placement Committee sends out are usually so general that they do a poor job of accurately demonstrating the individuals' qualifications. Prospective employers usually have to read between the lines of the resumes to try to determine if the people are qualified for their position. However, if interested individuals will tailor their resume to emphasize what the prospective employer is seeking, then the probability of a HGS member getting hired will be much greater.

THE KEY TO EFFECTIVELY USING THE JOBS HOTLINE

To make the jobs hotline effective, members interested in using the service must respond to each job request individually. Just faxing in the same generalized resume will not insure that it will be included in the group that is sent to the prospective employer. The key, once again, is to respond separately to each job request by emphasing your actual experience that is similar to the qualifications being requested.

Until the jobs hotline is proven successful, the Personnel Placement Committee will supplement the resumes that are faxed in with those presently on file. Please call frequently to see if any new job requests have been added.

HGS MEMORIAL GRADUATE SCHOLARSHIP FUND

The HGS and the Memorial Scholarship Fund Board gratefully acknowlege the following contributions to the Fund. The three categories of contributions are Patron ($500 or more), Donor ($100 to $500) and Contributor (less than $100).

Patron
BHP Petroleum

Donors
Ralph R. McLeod
Mitchell Energy & Development Corp.

Contributors
Cyrus Strong
Jack Colle (in memory of Mrs. Jack Colle)
Houston Geological Society (in memory of James C. Barker)
Yoshikazu Yaguchi

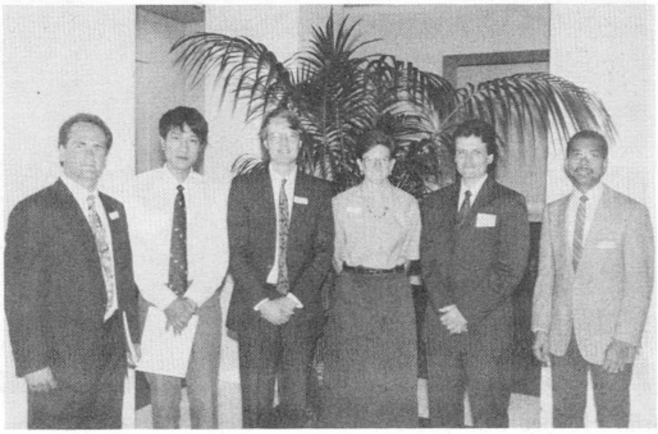
OUTSTANDING STUDENT AWARDEES 1991-1992

Students from six local universities were presented with HGS Outstanding Student Awards at our dinner meeting on April 13th. Each student received a check for $250 from the society as well as recognition in the April *Bulletin*. Pictured from left to right, the winners are: Phillip Hayes (Texas A&M), Zhongfang Liu (Stephen F. Austin), Everett Rutherford (University of Houston), Denise Apperson (University of Texas), Rob Borel (Lamar), and Kenneth Abdulah (Rice).

The students were also invited to participate in a review of Shell Oil Company's research and exploration facilities in Houston. Several participated. Special thanks go out to David Haglund at Shell for coordinating the field trip.

The HGS Awards Committee is trying to find a company to participate in the student field trip program next year. For more information, please contact John Adamick.

JOHN A. ADAMICK, Awards Chairman



1991-1992 Outstanding Student Awards

AAPG AWARDS 50 YEAR MEMBERS

The AAPG recently honored 15 HGS members in recognition of their 50th anniversary as members of the AAPG. The awardees received a gold lapel pin from AAPG president Dr. Robert Weimer. These "pioneers" of the oil and gas industry include:

John C. Baxter
Hart Brown
William F. Cooke, Jr.
Anne R. Frank
Donald W. Franklin
James J. Halbouty
George C. Hardin, Jr.
Robert W. Hopf
Edward R. Kemp
Wendell L. Lewis
Richard C. Marmduke
Forrest M. McClain
Orville G. McClain
Claude M. Quigley, Jr.
James I. Riddle, Jr.

Congratulations to these long-term supporters of the AAPG.

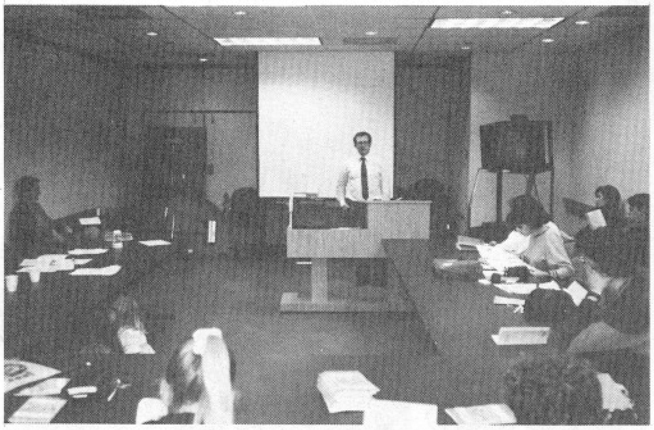
JOHN A. ADAMICK, Awards Chairman

EXPLORER POST NEWS

On February 13, Arlin Howles of Roy F. Weston Inc., and Bob Rieser of Groundwater Technology presented a program to Explorers from Posts 2004 and 2005 to introduce possible career opportunities in the environmental field. The program was followed by a question and answer session where Arlin and Bob explained the many facets of the business which could incorporate any number of career choices. A special thank-you goes out to Arlin and Bob.

Congratulations go to Cindy Lo, a sophomore at Jersey Village High School. Cindy was recently awarded the Young American Award from the local Exploring Council for her academic achievement and extracurricular involvement. Cindy is Treasurer of Post 2004.

Explorers from both posts are gearing up for their Superactivity trip to the Smoky Mountains this summer. Fundraisers are in full swing in hopes of raising enough money for this week-long event.



Arlin Howles addresses Explorer Posts 2004 & 2005 on career opportunities in the Environmental field.

Cindy Lo displays her Young American Award. Also present are Dan Helton (Post Advisor), Leslie Farias, Troy Tompkins, and Denise Flinn.

HGS 25 & 50 YEAR MEMBERS

Twenty-five HGS members were honored at the May 11th dinner meeting in recognition of their long-term membership in the Houston Geological Society. President Cy Strong presented awardees with 50-year or 25-year membership certificates, depending on length of membership. Those qualifying for the award include:

50 YEAR MEMBERSHIP

Almer F. Childers	John E. Huff, Jr.
Jack O. Colle	Benjamin T. Simmons

25 YEAR MEMBERSHIP

Chester A. Baird	John R. Harmonson
Michael A. Barnes	Sumner B. (Dave) Hixon
Robert R. Berg	Berton W. Hoyt
William F. Bishop	Andrew C. Jurasin
George R. Fluke	Howard W. Kiatta
William E. Gipson	John A. Montgomery
Paul J. Moore	Robert L. Smith
Lewis J. Nelson	Robert N. Tench
Kenneth B. Richardson	Byron L. Tolar

If you come across any of these individuals, be sure to give them a pat on the back for their long-term support of the Society.

JOHN A. ADAMICK, Awards Chairman

SCIENCE OLYMPIAD

The HGS made a cash donation and offered volunteer judges this year to the Texas Science Olympiad Program. The Olympiad contest is devoted to improving the quality of science education, increasing student interest in science and providing recognition for outstanding achievement in science education by both students and teachers. This year over 1400 students from 50 different schools participated in the event, which was held in January on the campus of San Jacinto College.

Students participated in events such as Rock and Fossil Identification, Science Bowl, Aerodynamics, "A is for Anatomy" and "Bridge Building". The winning school for grades 6-8 was Westview Middle School and the winner for grades 9-12 was Langham Creek.

Congratulations to these two schools for academic excellence and to Dr. Raymond Crawford, director of the Texas Science Olympiad for another successful event.

JOHN A. ADAMICK, Awards Chairman

HGS UNDERGRADUATE SCHOLARSHIP FOUNDATION GIVES SIX SCHOLARSHIPS

The HGS Undergraduate Scholarship Foundation awarded six scholarships to students from local universities for the 1991-92 academic year. These students were honored at the HGS January dinner meeting and are to be commended for their accomplishments.

ROB BOREL
Lamar University

Rob is a senior at Lamar University and plans to continue his education and eventually obtain a Ph.D. in geology. He is presently the President of the Lamar Geological Society, a student assistant, and a physical and historical geology lab instructor. His interests are mineralogy, mining geology, petroleum geology and environmental studies.

CAREN CHAIKA
Rice University

Caren is a junior at Rice University and plans to continue her studies after graduation in the spring of 1993, obtaining a Masters or Ph.D. Caren has worked as a lab assistant at Rice and was also a summer intern last year for Exxon in the Alaska Interest Organization.

SCOTT RUBIN
The University of Texas at Austin

Scott is a senior at the University of Texas with a 3.95 GPA in the Geophysical/Hydrogeology program. He was selected as one of 14 students for the 1990 summer intern program at NASA's Lunar Planetary Institute in Houston. His research concentrated on modeling meteoroid collisions and is to be published. He has also worked for an environmental consulting firm during the summer.

MICHAEL THOMPSON
University of Houston

Michael is a junior at the University of Houston and expects to graduate the spring or fall of 1993. Michael works off campus at least twenty hours a week to pay for his education, in addition to taking a heavy course load. He is very concerned about our environment and wishes to have a career where he can be of service.

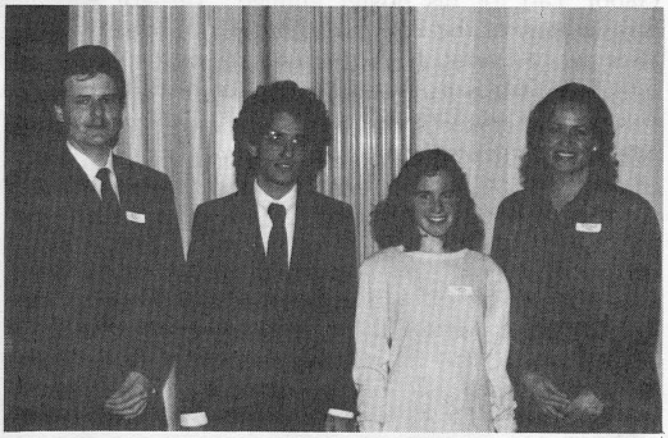
EGON WEBER
Texas A&M University

Egon is a senior at Texas A&M and will attend graduate school after a May graduation. He plans to get a doctorate degree in geochemistry with a probable career in resource management. He has spent time working for the Texas A&M Ocean Drilling Program researching the Earth's paleoclimate.

DEBERAH WHITE
Stephen F. Austin State University

Deberah is a junior at Stephen F. Austin State University and is pursuing a major in geology with an environmental emphasis. In addition to maintaining her good grades, Deberah is the coordinator of the Physical Geography laboratory and is the single mother of a sixteen-year-old daughter. Deberah has been a rock/mineral/fossil collector for as long as she can remember and looks forward to receiving her geology degree.

In addition to the Undergraduate Scholarship Awards, Hugh Hardy presented an award to Merrill Haas for his inspiring and exemplary leadership during his tenure as chairman of the Foundation, May 1984 - July 1991. He has been unanimously elected Chairman Emeritus of the Foundation.



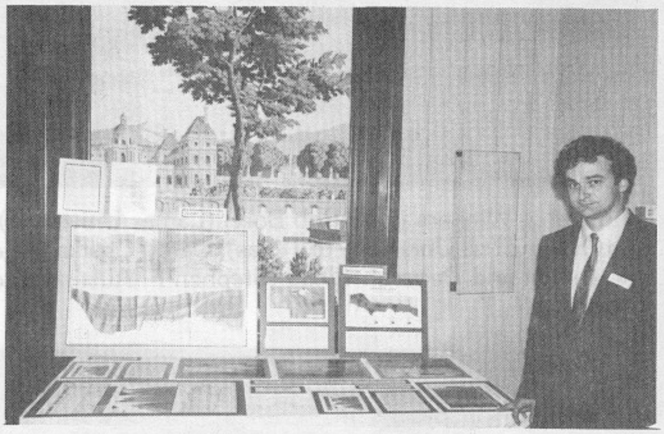
Scholarship Winners (L-R) Rob Borel (Lamar University), Scott Rubin (The University of Texas), Caren Chaika (Rice University), and Deberah White (Stephen F. Austin State University).

Hugh Hardy, Chairman of HGS Undergraduate Scholarship Foundation presenting award to Merrill Haas, Chairman Emeritus.

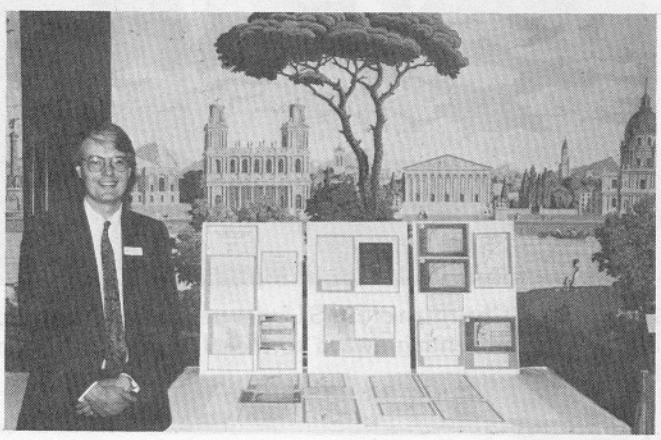
STUDENT POSTER AWARDS

The Awards Committee gave cash awards totaling $250 for student posters presented at the April 13th dinner meeting. Students presenting posters at the session included: Joan Flinch and Gabor Tari, Rice University; Rob Borel, Lamar University; Mark Connolly and Chuck Thornton, Texas A&M; Everett Rutherford and Paul Buchanan, University of Houston. First Place went to Gabor Tari for his poster entitled "Tertiary Sequence Stratigraphy of the Pannonian Basin". Second Place was awarded to Everett Rutherford for his poster "Computer Simulation of Hydrothermal Alteration of 87/86 Sr Ratios Near Mid-Ocean Ridges."

JOHN A. ADAMICK, Awards Chairman



1st Place Poster - Gabor Tari, Rice University



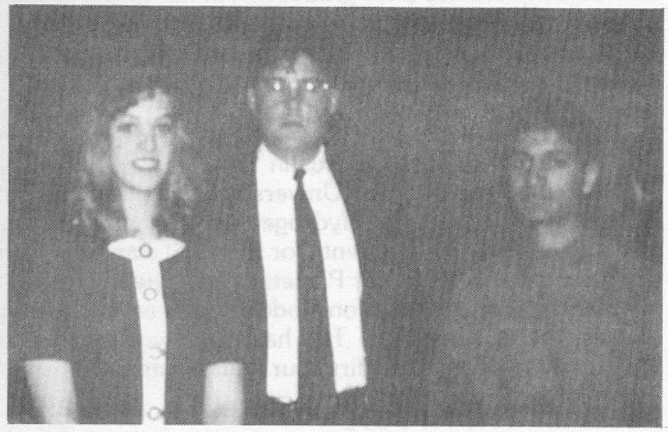
2nd Place Poster - Everett Rutherford, U of H

SCIENCE AND ENGINEERING FAIR 1992

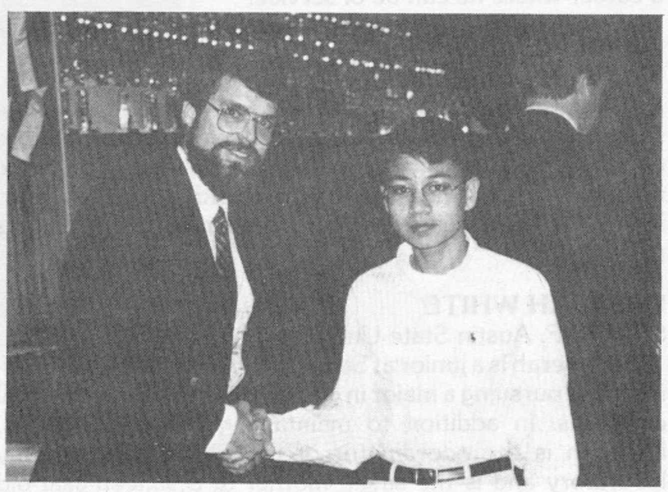
The HGS Awards and Environmental Committees participated in the Science and Engineering Fair on April 3rd at the Astroarena Hall. Seven judges awarded first and second place to students competing in earth/space and environmental science categories. Certificates, textbooks, and letters of recommendation were awarded to Junior, Ninth, and Senior Divisions. The HGS also made a cash contribution to help sponsor the event.

Participating judges were: Michele Bishop, Elizabeth Strathouse, Nester Philips, Carl Taylor, Kenneth Thies, Bob Rieser, and John Hollins. John Adamick, Bob Rieser, and John Hollins made the awards presentation to the students.

The enthusiasm exhibited by the students made this a rewarding event and congratulations are due to all students who participated. Thanks to all HGS members who volunteered their time.



John Hollins (center) with Kim McKinnis (1st place-Ninth Grade Division) and Vijai Yelundur (2nd place-Senior Division).



Environmental Committee Chairman Bob Rieser congratulates winner Jimmy Doan (2nd place-Senior Division Environmental Science).

Productive Low Resistivity and Unconventional Petrophysical Well Logs of the Offshore Gulf of Mexico

Houston Geological Society / New Orleans Geological Society

Project Committee

Clint Moore
Project Chairman
Anadarko Petroleum Corp.
P.O. Box 4499
Houston, Texas 77210-4499
(713) 874-8730

Richard Berlitz
Schlumberger Well Services
5005 Mitchelldale, Ste. #280
Houston, Texas 77092
(713) 957-6633

Bill Blair
Schlumberger Well Services
365 Canal St., Suite #2214
New Orleans, Louisiana 70130
(504) 592-5372

Harold Darling
Schlumberger Well Services
P.O. Box 2175
Houston, Texas 77252-2175
(713) 928-4000

Bob Douglas
Bob Douglas Exploration, Inc.
P.O. Box 1059
Destrehan, Louisiana 70047
(504) 764-7463

W.A. Hill
HGS Tech. Pubs. Chmn.
Arco Oil & Gas Co.
P.O. Box 1346
Houston, Texas 77251
(713) 584-6436

Glen Shelton
NOGS Tech. Pubs. Subcom. Chmn.
Chevron USA
P.O. Box 6056
New Orleans, Louisiana 70174
(504) 364-2305

Robert Sneider
Sneider Expoloration Inc.
11767 Katy Freeway, Suite 300
Houston, Texas 77079
(713) 531-9944

LAST CHANCE TO VOLUNTEER

TO HELP CREATE A TRULY HISTORIC GUIDEBOOK!

The HGS/NOGS Guidebook of "Productive Low Resistivity and Unconventional Petrophysical Well Logs of the Offshore Gulf of Mexico" is really taking shape!

The Steering Committee has been shown over 200 examples, almost all of which will impress even the most pessimistic formation evaluators.

Even though we've received tremendous cooperation and encouragement from nearly everyone, not even the large companies have the drafting time to submit as many examples as everyone would like.

This is where you could come in and be an official contributor!

Since all the data we're publishing is in the public domain, we have been encouraged by many companies to tell you where their qualifying pay zones are located, then have you borrow (or even buy) the logs and core analyses, and draft them up (manually or digitally) using our easy-to-use format sheets.

If you do the work, it is your submitted example!

We even have an Autocad version of our format sheet to make it even easier, and we'll be glad to send you the diskette.

So call a committee member today and volunteer for a truly worthwhile effort.

We all need your help to make this a tremendous guidebook!

CALL US TODAY!

Houston Address: 7171 Harwin • Suite 314 • Houston, Texas 77036 • (713) 785-6402
New Orleans Address: P.O. Box 52172 • New Orleans, Louisiana 70152 • (504) 561-8980

HONORARY LIFE AWARD 1991-1992

The Executive Board of the Houston Geological Society takes pleasure in announcing that Dietmar "Deet" Schumacher has been elected an Honorary Life Member. Honorary Life Membership is bestowed upon persons who have distinguished themselves in the science of geology, or who have contributed outstanding service to the success and welfare of this organization. A citation and plaque will be presented at our Guest Night Dinner Meeting on June 5th.

DIETMAR "DEET" SCHUMACHER HONORARY LIFE MEMBERSHIP

In being awarded Honorary Life Membership, highest award of the Houston Geological Society, Dietmar "Deet" Schumacher has come a long way, and we are indeed fortunate that he has come our way. Through his unswerving dedication and enthusiastic participation in Society activities, we have all benefited greatly and the Society has been strengthened and improved.

Deet was born in Yugoslavia (Croatia) in 1942, during some of the worst days of World War II. His family was displaced by the war's disruption and moved to Austria. In 1951, when Deet was nine years old, they emigrated from Austria to the United States where they settled in Milwaukee, Wisconsin. During his early teens Deet developed an interest in geology which blossomed into his career and life's work.

He attended the University of Wisconsin from which he earned B.S. and M.S. degrees in geology in 1964 and 1967 respectively. From Wisconsin he moved to the University of Missouri at Columbia where, in 1972, he earned his Ph.D. degree in geology.

He took a teaching position as a paleontologist at the University of Arizona in Tucson in 1970 while finishing his Ph.D. dissertation and, until 1977, taught courses in micropaleontology, invertebrate paleontology, biostratigraphy, paleoecology and historical geology. In 1977 he joined Phillips Petroleum as a research geologist in Bartlesville, Oklahoma and rose to the position of Supervisor for Petroleum Geology. The Houston Geological Society got lucky in 1981 when Phillips transferred Deet to Houston as a Geological Specialist. He met Jerry Cooley shortly after his arrival in Houston, and Jerry enlisted him into the wide world of HGS activities. He has been involved in HGS programs ever since.

Deet went to work for Pennzoil in 1982 and served as manager of geology/geochemistry before transferring to assignments with Pennzoil International, Pennzoil Offshore and, most recently, Pennzoil New Ventures.

It is certainly appropriate that Deet receive the HGS Honorary Life Membership Award. His professional activities are a litany of involvement. He started working for the HGS on the technical program committee and eventually became chairman of it plus several other committees along the way. He has served as Editor of the *Bulletin*, Vice President, President-Elect and, during the 1988-89 term, President of HGS. Most recently, he chaired the special Constitution and Bylaws *ad hoc* committee.

In addition to his HGS activities, Deet has been involved in a wide variety of other professional activities, the scope of which is most impressive. He has authored or co-authored thirteen published articles, numerous abstracts and field trip guides. His topics have been quite varied and give a clue to the breadth of his knowledge and interest. They include Devonian stratigraphy, conodonts, fossil sponges, Gulf Coast oils and gases, magnetic reversals and seismic sequence boundaries. He has had a long-standing interest in the exploration applications of geochemistry, particularly as applied to frontier basins. He shares this interest by teaching short courses at AAPG conventions and to various geological societies where he is in high demand. At the Gulf Coast Association of Geological Societies' convention in Houston last fall, Deet, with N. Rosen, was Editor of the 750-page GCAGS Transactions, Volume 41.

Deet also has done his share of work for AAPG. He has been a Delegate, representing the HGS, a member of the Distinguished Lecture committee and was chairman of the Matson Award committee when the AAPG convention was held in Houston in 1988. At the upcoming AAPG convention in Calgary he will teach a one-day short course entitled "Surface Exploration for Oil and Gas." Amidst all his other activities he was an outstanding member of the AAPG 21st Century Committee which completed its report last year.

Credit for Deet's many accomplishments also is shared with his wife Carol, a native Houstonian, who has encouraged him in his endeavors. Carol is an accomplished weaver and spinner and is a member of the Houston Geological Auxiliary.

Deet is an outstanding geological professional who has shown his happiness in his life's work and dedication to the profession by giving of himself to the professional societies. We have all been enriched by having him with us. In honoring him with Honorary Life Membership, the Houston Geological Society also honors itself.

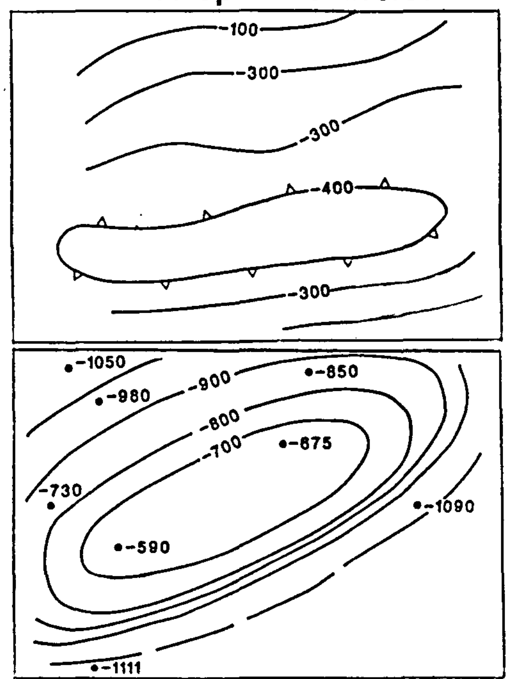
JOHN J. AMORUSO

HGS SHORT COURSE SEPTEMBER 29, 1992

Contouring Workshop

For inexperienced mappers and those wishing a refresher, The Houston Geological Society will sponsor a one day continuing education course entitled **"Contouring Workshop"**. After a short review of methods of contouring subsurface data, Jim Clement will assist participants in self-paced hands-on exercises that simulate typical oil and gas-field maps.

Can You Spot The Errors?

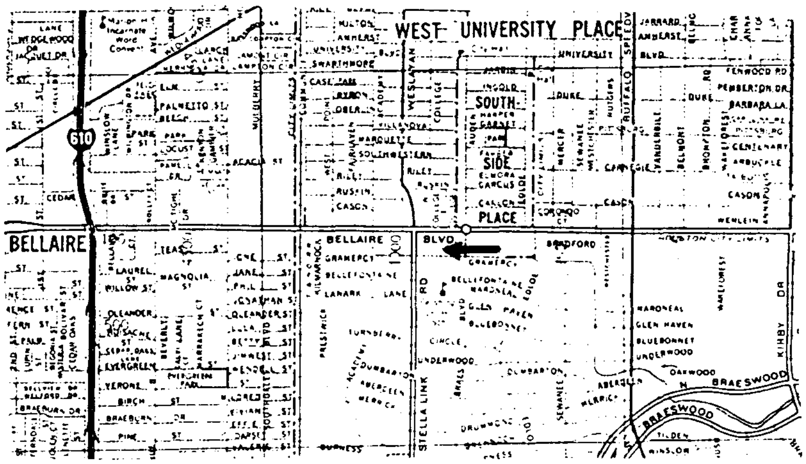


__Your Instructor__

Jim Clement is retired from Shell Oil, where he held various technical and management positions in Exploration. His last position was as Manager Geology Training, where he presented this workshop to generations of Shell geologists.

__Location__

Shell Oil Training Center, The Braes Heights Building, 3837 Bellaire Boulevard (at Stella Link). Upstairs, next to I.W. Marks Jewelers. Park in St. Mark's Church parking lot across the street.



__YOU WILL LEARN HOW TO__:

*Construct free flowing contours by hand

*Recognize errors and problems with pre-existing contour maps

*Map intersections of two or more contour surfaces

*Appreciate how various contour styles may impact offset locations.

__Cost__: **$40 in advance, Advance Registration Only.** Enrollment is limited to 40. If you pre-register, but find that you cannot attend, please advise us so that space reserved for you in the course is not wasted, and your money can be refunded.

Date and Time:

Tuesday, September 29, 1992, 8:30 am to 4:00 pm. __Please be on time__.

Sponsored by the Continuing Education Committee of your Houston Geological Society

Please make check payable to:

Houston Geological Society
7171 Harwin, Suite 314
Houston, Texas 77036

Registration Form Contouring Workshop by Jim Clement

Name ____________________

Address ____________________

City, State, Zip ____________________

Home Phone __________ Office Phone __________

DISTINGUISHED SERVICE AWARDS 1991-1992

The Executive Board of the Houston Geological Society is pleased to announce that Dan Smith and Dick Bishop have been elected to receive the Distinguished Service Award. This award was established to honor members who have rendered long-term and valuable service to the Society. A citation and plaque will be presented at the Guest Night Dinner on June 5th.

DANIEL L. "DAN" SMITH DISTINGUISHED SERVICE AWARD

Photo by Kugler

Dan Smith has led a distinguished and active career from his Eagle Scout youth to present day multiple duties chairing several key SIPES Committees and the HGS Memorial Scholarship Board. All this in addition to distinguishing himself as a successful petroleum exploration company executive and currently a successful exploration independent, consulting for Texas Meridian Resources Corporation. Dan is a member of many Gulf Coast Geological Societies and is a member of SIPES, AIPG and AAPG.

I first met Dan at Amoco in Houston (1966) where he worked as a successful young Geologist from 1958-67 after graduating from the University of Texas in 1958. He worked in Corpus Christi, New Orleans and Houston with emphasis on South Louisiana. He set up Amoco's first practical computer geological study on the Upper Cretaceous Sand Trend in South Texas. From 1970, he helped build Texoil to a mid-sized aggressive exploration team featuring ten geologists responsible for discoveries at Buras, Kenner, Pointe A la Hache, Diamond, Bayou Villars, Dorcyville and elsewhere. He is currently associated with Texas Meridian primarily working South Louisiana where, I am sure, he will continue to be successful. Through these years he and his lovely wife, Laura, have raised three beautiful daughters and a fine son, with whom he was able to traverse the scouting program once again.

In 1982, Dan made the decision to repay his profession for his success by becoming active in the Houston Geological Society and SIPES. He has been an AAPG delegate several terms and foreman in 1985. He was Vice President and Technical Chairman of HGS in 1986, President-elect in 1987, President in 1988. In 1989 and 1990 he served as Vice President and President for the local SIPES Chapter. He served with me on the HGS nominating committee during the same period, and we subsequently Co-chaired the GCAGS Convention in Houston in 1991. Laura, Dan's wife, developed the title and logo "Winds of Change" for that very successful meeting.

In the past two years Dan's activities with SIPES include serving on the Board of Directors (National), chairing the National Energy Advisory Council, chairing the

Continued on page 56

RICHARD S. BISHOP DISTINGUISHED SERVICE AWARD

Every geologist I've met is proud of his profession. Some geologists give more back to their profession than others. Richard S. Bishop whom we all know as Dick stands first in line of those I've known who, not only desire to make our profession better, but have always been willing to give time and talents to further this goal. Dick's strong commitment to professional enhancement is a product of good intellect, hard work and a great deal of nurturing by parents, teachers, peers, mentors and his wife. Both of Dick's parents are earth scientists: his father a geophysicist, and his mother, Dr. Margaret Bishop, a longtime professor of geology at the University of Houston. Dick's wife Edie has supported him (literally while at Stanford University) during his studies and professional development. It's been said "much is expected of those to whom much has been given". That's how our system is designed to work — and work well it did.

After joining HGS, Dick's first contribution was the presentation of a paper on shale diapirism in 1978. When asked to be Editor (1981-83) of the HGS *Bulletin* and expand its scope and quality, without any experience, Dick accepted. With the help of Jerry Watson, Susan Morris, Cindy Langstaff and Deet Schumacher, an expanded and improved *Bulletin* was achieved. It was this experience that taught Dick the power of accomplishment possible when a group of geologists believe in a common goal. This lesson served Dick admirably well during his leadership as Chairman of the AAPG Annual Convention held in Houston in the spring of 1988. Planning and coordination for such an event begins two years prior to the meeting. By coordinating and grouping the best in each area of expertise, the 1988 meeting represented a major resurgence of interest and activities for the Houston Convention which followed two disappointing meetings. Dick further demonstrated his administrative and leadership skills while serving as President-elect and finally as President of the HGS in 1990-91.

One of Dick's most outstanding contributions to the HGS has been his vision and leadership in establishing a sense of urgency for improvement within an all-volunteer

Continued on page 56

HGS GOLF TOURNAMENT
September 28, 1992

PLACE: Kingwood Country Club

FORMAT: Four Man Scramble

FEATURING:
* Closest to the pin contests
* Longest drive contests
* Putting contests
* Trophies, Awards, & Prizes
* Refreshment stands
* Bar-B-Q dinner
* Betting holes

This year's tournament will be a four-man scramble. A shotgun start at 11:45 a.m. using all three courses will be followed by an informal buffet dinner with presentation of awards. A player may select his/her own foursome or be placed in a foursome by the tournament committee. The field will be split into flights according to handicap and thus be placed on one of the three courses.

Entries will be limited to the first 108 four-man teams entered (432 total golfers), and will be accepted on a first-in basis. ONLY three courses will be used — so enter quickly!

Entry fee will be $70.00 for HGS members and $85.00 for non-members. (Membership verified by computer listing; check with the Geological Society at 785-6402 about member status if there is any doubt.) The deadline for entries is September 18, 1992, or when tournament is full. Entry fee includes green fees, golf carts, driving range use with practice balls, and the buffet award dinner. So get your group together, come out and enjoy the competition, food, and fun.

Companies interested in sponsoring, or people interested in helping should contact tournament chairman Chris Bechtel, with OMNI Laboratories Inc. at 862-2400.

To enter, fill out the following entry blank and mail with your entry fee (payable to HGS Entertainment Fund) to:

Chris Bechtel
OMNI Laboratories, Inc.
6955 Portwest
Suite #100
Houston, Texas 77024

All entries will be acknowledged by return phone call the week of September 21st.

Name ______________________ Amount Enclosed ______________________

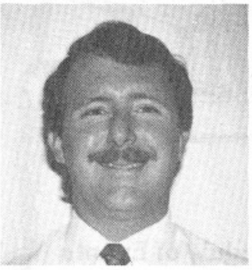
Company ______________________ Phone ______________________

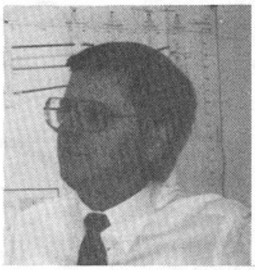
	Foursome Members (Please Print)	HGS member	Non member	Company	Handicap or Average Score
1.					
2.					
3.					
4.					

PRESIDENT'S AWARDS
1991-1992

Each year, certain individuals stand out for their efforts and their unique contributions to the presidency of the Houston Geological Society. Those designated by the president are cited for continuing excellence or for a one-time contribution. It is intended that this award be an expression of the President's esteem and appreciation. In order to maintain a high standard for the award, no more than five awards can be given in any one year, and Executive Board approval is required. These awards will be presented at the June 5th dinner meeting.

The President's Awards were established in 1987 by President Chuck Noll to recognize especially significant service to the Houston Geological Society. This year the awardees are:


John A. Adamick


David Fontaine


John Merritt Gorman


Jim Lantz


Martin J. Oldani

John A. Adamick

John A. Adamick currently serves as Chairman of the HGS Awards Committee. He and his committee members are responsible for preparing, distributing, and presenting most HGS awards. They also frequently serve as judges for various HGS events. John is also a member of the HGS Undergraduate Scholarship Committee and has served as a member of the Awards and Arrangements Committee. In 1991, John served as Chairman of the GCAGS Housing Committee. He is a former HGS Outstanding Student awardee and a recipient of the HGS Memorial Graduate Scholarship.

David Fontaine

David Fontaine continues to direct the consulting group he established in 1981 following a career at Conoco as a development geologist and economist. He is a Rutgers graduate with an M.S. in geology awarded in 1976, and is a state-licensed geologist in Florida. His business focus is the evaluation and appraisal of energy projects, and he assists foreign companies with their energy-related business activities in Texas.

Dave has published technical summaries on the occurrence of oil and gas, and is periodically a featured speaker before professional societies and client organizations. He is HGS Finance Committee chairman and serves on the Advisory Board of the Division of Professional Affairs of the AAPG.

John Merritt Gorman

John received his B.S. in Geology/Philosophy from the State University of New York College at Oneonta and his MBA degree from Houston Baptist University. He is currently working as a GeoScience Systems Analyst, doing customer support for Landmark Graphics, Inc.

John began working the HGS/GSH Shrimp Peel in 1981 as a kitchen helper. He was then asked to co-chair the event, as the chairman wanted to resign. After co-chairing in 1982, John has chaired the event by himself, even while living in New Mexico, but with the cooperation of many long-term volunteers and the cooks from NL-Baroid, without whom the event could not run smoothly.

Enduring the downturn in the industry, this event continues to be the biggest and most successful social event of the HGS year, bringing together the members of HGS and GSH for an evening of good food, good music and good fun.

Jim Lantz

Jim Lantz grew up in the cool hills of Vermont and moved to the rolling prairies of Texas in 1976. He has been employed as a geologist with Amoco Production Company for the past 12 years. His current position is Senior Staff Geologist in the International Business Unit, and Team Leader of the Teak Field, Trinidad Reservoir Development Team. Jim holds a B.A. degree in geology from the University of Vermont, and an M.S. degree in geology from Texas A&M University where he was a student in the Center for Tectonophysics. Jim has had a strong interest in continuing education, serving as a member of the HGS Continuing Education Committee since 1987, and as its chairman for the past two years.

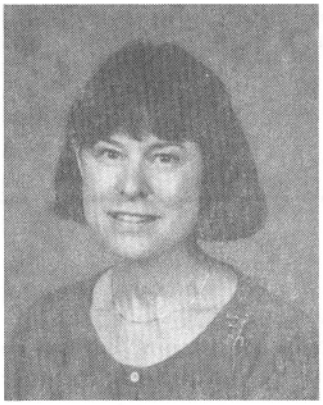
Martin J. Oldani

Martin J. Oldani is entering his second year as Chairman of the HGS Entertainment Committee. In this role, Martin coordinates the activities of a variety of subcommittees which run the various HGS Entertainment events during the year. Previously, Martin served the HGS as Secretary of the Society during the 1988-89 and 89-90 years. Martin has been continuously involved with the field trip committee since 1986, most recently serving as Field Trip Chairman for the GCAGS Convention held here in Houston this past October. Professionally, Martin is currently a Senior Staff Geologist with Apache Corporation and received both his B.S. and M.S. degrees in Geology from Baylor University.

EARTH SCIENCE TEACHER AWARD 1991-1992

The Executive Board of the Houston Geological Society is pleased to announce that Joyce Ramig has been elected to receive the 1991-1992 Earth Science Teacher Award. This award was established to honor the efforts of earth science teachers from junior and senior high schools in the Houston area. A citation, plaque, and cash award will be presented at the Guest Night Meeting on June 5th.

JOYCE RAMIG EARTH SCIENCE TEACHER AWARD



Joyce Ramig graduated from Oregon State University in 1967 with a BS in Education. She has taken graduate courses from the University of Colorado and Boston University. In 1982 she was chosen to participate in Houston ISD Project Search, where she took courses to qualify as a middle school science teacher. She continued taking science courses at Houston Community College through 1984 and was a participant in the Shell Oil Program for science teachers in 1985. Joyce is presently working at the University of Houston on an MS degree in Science Education. She was chosen to participate in a special Eisenhower Grant class on Galveston Bay for spring and summer 1992 and to participate in a special NSF Grant class on Science, Technology, and Society for summer 1992. Joyce was a participant in seminars on astronomy, water quality, geology, Galveston Bay, and electric power at the Rice Model Lab. She studied at Texas A&M in Galveston about concepts necessary for a Galveston Bay unit. Recently she toured an urban salt marsh in Boston, and spent a day learning from scientists at Woods Hole. Joyce is a frequent participant in conferences for science teachers.

Joyce is presently a resident teacher in the Rice Model Lab, where she teaches seventh grade students. Next year she will resume teaching seventh and eighth grade students at T.H. Rogers School, where she has been an earth science teacher for nine years. Before becoming a science teacher, Joyce taught first and second graders in Oregon, Colorado, New York, Massachusetts, and Texas.

Joyce has maintained a high involvement with her middle school students. She was National Junior Honor Society sponsor at Rogers for five years. She also helped students plan the United Way Kids' Way Drives at Rogers. Joyce has sponsored a science club at Rogers, and she planned and implemented a Halley's Comet, star party in 1986.

Joyce is associated with a number of professional organizations. These include National Science Teachers Association, Science Teachers Association of Texas, Metropolitan Association for Teachers of Science, Texas Environmental Education Association, National Earth Science Teachers Association, Texas Earth Science Teachers Association, National Middle Level Science Teachers Association, Congress of Houston Teachers, and The Delta Kappa Gamma Society International. She was a member of Houston 1991 National Meeting Local Arrangements Committee and planned services for people with disabilities for the National Science Teachers Association national convention.

Teacher education has always been an important part of Joyce's career. She was cooperating teacher for student teachers from the University of Houston and Kearny State College, while at Rogers. She was also cooperating teacher for student teachers from Boston State College, Boston University, Northeastern University, Emerson College, and Wheelock College. She was District Coordinator for student teachers from the University of Colorado and cooperating teacher for several students from that university. Joyce was a contributor to the Share-a-Thon at the fall CAST/TESTA conference, a presenter at the spring TESTA conference, and was recently chosen to participate with a small group of specialists in reviewing the American Chemical Society's FACETS curriculum. She has been a presenter in ten in-services for 100 Houston ISD science teachers at the Rice Model Lab, and she will participate in providing in-service training for these teachers next year. She will also provide monthly in-service training on the FACETS curriculum for twenty Houston area science teachers. Joyce plans to be a presenter at several national and local science meetings in the coming year, and she hopes to continue serving as a cooperating teacher.

UH FALL COURSES

The Department of Geosciences at the University of Houston is offereing the following courses of possible interest to HGS members for the Fall semester, 1992. Registration on campus will be on August 3 and 4. For more information, please contact Mrs. Cassandra Heavrin at 743-3401.

Course Number	Time	Course Title (Instructor)
4330	5:30-7 TTH	Intro to Geophysics (Sheriff)
4358	4-5:30 MW	Intro to Depositional Models (Chefetz)
4379	5:30-7 MW	Groundwater & Engr. Geophysics (Hall)
4397	5:30-7 TTH	Engr/Environmental Geology (Dupre´ & Norman)
6345	5:30-7 MW	Hydrochemistry (Capuano)
6362	5:30-7 TTH	Computer Modeling (Woronow)
6366	4-5:30 MW	Hydrogeology (Capuano)
6377	5:30-8 W	Space Geology I (King)
6382	7-8:30 TTH	Plate Tectonics (Casey)
6383	5:30-7 TTH	Intro to Basin Analysis (Burke)
6386	4-5:30 TTH	Igneous Petrogenesis & Tectonics (Casey)
6397	4-5:30 MW	Topics in Earth Physics (Hall)
6397	4-5:30 TTH	Seismic Tomography (Zhou)
6397	5:30-7 TTH	Geophysical Data Processing (McDonald)
7320	7-8:30 TTH	Seismic Velocity (Noponen)
7332	5:30-7 MW	Prin-Seismic Wave Prop (Sheriff)

Daniel L. Smith, continued from page 52

Committee on registration and certification, and Secretary of the National organization and of the SIPES Foundation. He keeps HGS and local AAPG delegates current on all state registration matters. Dan is obviously one of our best informed and most active petroleum geologists, and we are fortunate to have him representing our constituency here in Houston. The Houston Geological Society is proud to honor him for his many contributions with the Distinguished Service Award.

CHARLES R. "CHUCK" NOLL

Richard S. Bishop, continued from page 52

(except for Margaret) organization. Dick's contagious commitment to serve our membership always extracted a high level of "quality" service from HGS Board and Committee members. Because of the scope of his vision for HGS some of the longer term projects (publications) are still underway.

Dick is a modest man who once said, "Everything that I accomplished . . . was through the work, ideas, initiatives . . . of others." Thus, a brief review of a few milestones accomplished by "others" is in order.

Scholarship - Dick had the idea and orchestrated the transfer of $30,000 from HGS to the Undergraduate Scholarship Fund. Dick had the idea, laid the foundation, and orchestrated GCAGS's participation in matching up to $10,000 in scholarship donations for all GCAGS member societies. Clyde Harrison and Merrill Haas were key players in this achievement.

Directory - Dick had the idea and initiated the goal of a joint HGS-GSH Membership directory. Key players in this achievement were Tom Clark, John Hefner and Margaret Blake.

Membership - Dick had the idea of a membership drive and recruited an energetic chairman (Bruce Falkenstein) who caused the membership to exceed 5,000 members.

Bulletin - Dick believed the *Bulletin* could be better. He recruited George Kronman who made it happen.

Entertainment - Dick believed the golf tournament could be bigger and better. Chris Bechtel and others made it happen.

Poster Session - Dick believed poster sessions would add to evening meetings. He recruited Pat Gordon who made it happen.

Guest Night - Dick believed guest night could be more entertaining for guests. He recruited Clint Moore who initiated the popular IMAX series.

Much more goes into the title of "professional" than mere technical expertise. Dick Bishop is a man of integrity, sound judgement, high morals, great intelligence and one whom we as an earth science organization are proud to honor. It is with pride and pleasure that we recognize the contributions Dick has made to our organization and to the profession of geology. He is a true professional in the broadest sense.

RON HARLAN

FEATURE

THE CASE FOR EARLY GENERATION AND ACCUMULATION OF OIL*

by H. H. Wilson
Banner Energy, 3000 Post Oak Boulevard, Suite 1600, Houston, Texas 77056, USA.

Uncertainties remain concerning the common assumption that economic oil pools result only from deep, catagenic oil generation. These uncertainties stem from the many geological criteria that point to early oil entrapment and, furthermore, from the failure to resolve problems of oil migration out of, and through, consolidated sediments.

Early oil emplacement is indicated by the preferential charging of paleostructures, inhibition of diagenesis and compaction by reservoired oil, folded oil-water contacts. and by evidence supporting the immaturity of huge heavy-oil deposits

The uncemented and uncompacted nature of the Athabasca "tar sands", the perfect preservation of fossil wood within them, and the tilted oil-water contacts at the Athabasca, Peace River and Cold Lake accumulations, support geological deductions of very-early oil emplacement, and geochemical criteria for its immaturity.

If such huge volumes of oil are immature, this would be in harmony with geological observations which conclude that pools of mature oil most probably result from in-reservoir maturation of early-expelled, biogenically-generated heavy oil and methane.

Hydrocarbons that remain in source rocks are maturated during burial, but are immobilised by progressive loss of effective permeability.

INTRODUCTION

About a century ago, Edward Orton (1888) reviewed the then-current theories of petroleum origin, migration and accumulation, which he summarized under the headings of "inorganic origin", "origin by high-temperature distillation of organic matter", and "origin by low-temperature decomposition of organic matter". Of these three alternatives, Orton concluded that the inorganic theory lacked credibility because it was propounded by chemists rather than geologists, and matched better with the chemical than with the geological facts. Orton concluded that the organic origin of petroleum was indisputable, but that oil-occurrence observations better supported the theory of generation by low-temperature decomposition of organic matter than the theory of high-temperature distillation.

Orton observed that no one theory commanded universal acceptance, and that often the reason for the existence of opposing theories was that they respectively regard only one side of a subject which in reality has many sides.

After ten decades of petroleum exploration, the development of ever-more sophisticated data-gathering technologies, and the discovery of thousands of oil- and gasfields around the world, the three competing theories of hydrocarbon generation discussed by Orton are still with us.

Sufficient support was garnered for the inorganic theory of origin to promote the recent, extremely-costly Siljan Ring deep test in Sweden. The two theories of organic origin have received much attention in petroleum-geological literature since Orton's day and, from time to time, comprehensive analyses of the time of oil generation and migration have been published by petroleum geologists whose professional stature should command our respect, for example: McCoy and Keyte (1934); Van Tuyl and Parker (1937, 1941); Levorsen (1954, p. 513-515); Weeks (1961); and Hedberg (1964, p. 1780). In all these analyses, the authors concluded that diverse geological data gathered from petroliferous basins around the world supported the conclusions that oil was generated early, at low temperatures, and that it accumulated in early-formed traps.

From the mid-1960's until today, geochemistry has been acknowledged by most geologists as the appropriate tool to resolve unequivocally the question of time of oil generation. This has led to the general acceptance of the distillation theory, on the basis of geochemists' assurances that oil in commercial quantities can only be generated catagenically from geochemically-identifiable source rocks.

The conflict between these geochemically-based conclusions, and geological observations that point to early oil generation and entrapment, were reviewed by the present Author (Wilson 1975,1982), and by Chapman (1983), both of whom stressed the compelling evidence for early generation of oil.

Nonetheless, the concept of early oil generation has steadily lost ground against the distillation theory, not because the geological observations of Weeks and others were inaccurate, but, as Jones (1980, p. 59) puts it, because the interpretations therefrom were made before the full advent of modern organic geochemistry. This conceptual turnaround has substantially effected exploration strategies, prospect identification and expenditures during the past twenty years.

The general acceptance of the distillation theory is surprising, since geoscientists have yet to provide a satisfactory explanation for primary oil migration from deeply-buried and lithified source rocks, and secondary

* *Reprinted with permission from* Journal of Petroleum Geology, *April, 1990, p. 127-156.*

migration from these to the ultimate traps (Tissot and Welte, 1978, p. 258). The mechanism of migration remains an "enigma" (Roberts and Cordell, 1980).

Given the lack of concensus on a fundamental process that is implicit in the distillation theory, geologists should beware of accepting catagenic generation and expulsion of oil as "fact" (Tissot and Welte, 1978, p. 287), and reflect upon Einstein's unwillingness to accept any unproven principle as self-evident, for it was in this way that he was able to penetrate closer to the underlying realities of Nature (Bennet, 1974, p. 58).

In any attempt to resolve these fundamental problems, it would be well to heed Orton's (1888) warning that opposing theories often evolve through over-emphasis of one side of a many-faceted problem. In a satisfactory solution, all relevant data must fit harmoniously together.

In the past ten years. many new data that bear upon problems of oil generation and migration have emerged, and these, coupled with information published in the past, provide a foundation for concluding, once again, that early generation and accumulation of hydrocarbons is a phenomenon that cannot be lightly dismissed. Indeed, evidence is presented here which again implies that early, low-temperature oil generation is the fundamental geological process that is responsible for today's economic oil pools.

The geologic foundations upon which this conclusion is based comprise data gathered on four principal petroleum-geological phenomena:

(i) The relationship of trap timing to oil and gas accumulation.
(ii) The contrast of diagenetic evolution and rock compaction within and outside oil and gas pools.
(iii) The occurrence of deformed oil-water contacts.
(iv) The evidence supporting the immaturity and early expulsion of huge deposits of heavy-oil and "tar".

It is timely to sound yet another warning note that not all is "cut and dried" in our understanding of oil generation, and geologists should not be reluctant to challenge the popular wisdom.

TRAP TIMING AND DISTRIBUTION OF HYDROCARBONS

The preferential occurrence of hydrocarbons in early-formed traps is an indisputable phenomenon that has been observed and recorded for many years, and has been discussed at length by McCoy and Keyte (1934), Weeks (1961), Wilson (1975, 1982), and many other geologists. This phenomenon, of itself, places timing constraints on hydrocarbon migration.

Many publications that today endeavour to explain hydrocarbon occurrence in a basin by late migration from "oil kitchens" indicate migration pathways leading to discovered fields; for example, the analysis of oil habitat in Abu Dhabi by Hassan and Azer (1985). Modern analyses such as these, which are based upon geochemical considerations, very seldom indicate the traps that lie along the hypothetical migration pathways, which are yet devoid of hydrocarbons, even though such preferential behaviour cries out for explanation.

Two excellent examples that illustrate the control of trap timing on oil occurrence are the relationship of dry Woodbine sands in the *Kelsey* anticline to the adjacent Woodbine accumulations in the *Hawkins Dome* and *East Texas* "super-giant" field (Denison *et al.* 1933); and the relationship of productive Zubair sands in the *Raudhatain* "super-giant" to barren Zubair sands in the adjacent *Sabriyah* field, Kuwait (Al Rawi, 1981).

The Kelsey anticline

Tests on the *Kelsey* anticline (Fig. 1) encountered water-bearing Woodbine sands without shows, despite isopach control that proved trap closure by Wilcox (Eocene) time (Denison *et al.*, 1933, p. 673).

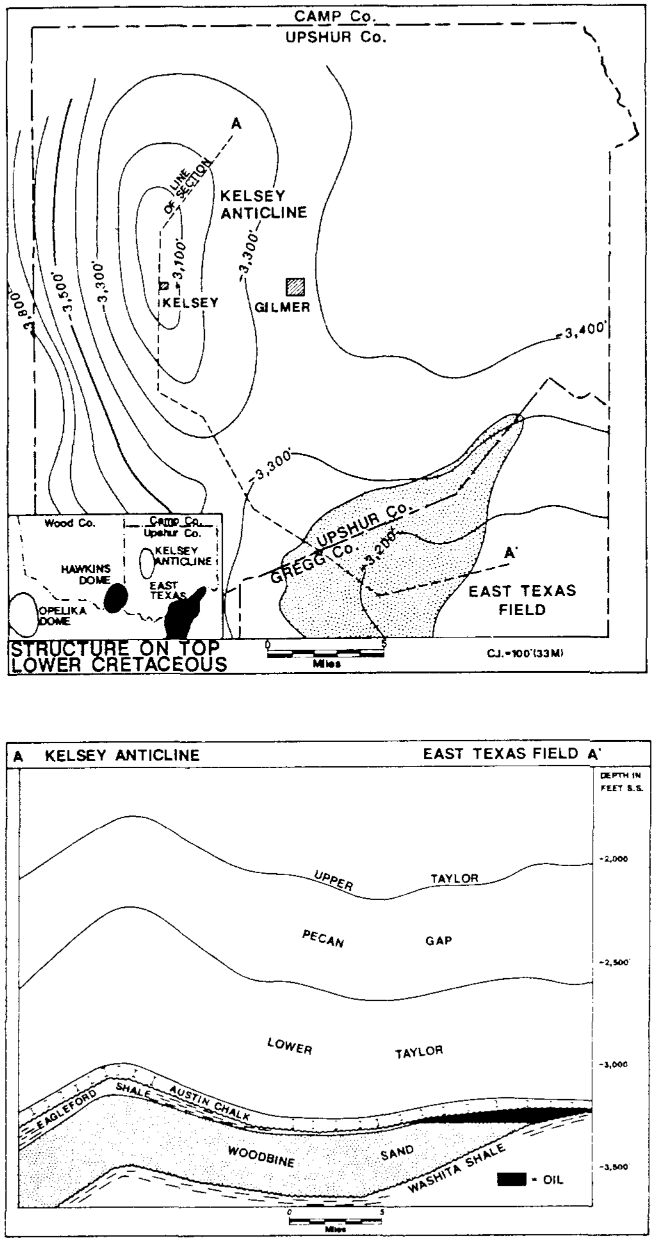


Fig 1. The *Kelsey* anticline, Upshur County, Texas. The map and corss-section illustrate the relationship of trap timing to hydrocarbon emplacement. The Woodbine sands are wet at *Kelsey* but oil-bearing in the adjacent, earlier traps at the *East Texas* and *Hawkins* fields. (After Denison *et al.*, 1938).

Isopachs over the *Hawkins Dome* on the other hand, showed that Woodbine sands were in a closed-trap position during or very shortly after their deposition, as a result of Late Cretaceous doming of underlying Louann salt (Wendlandt *et al.*, 1946).

The truncated Woodbine sands of the *East Texas* "super-giant" were effectively sealed up-dip by transgressive Austin chalk in Coniacian time, after which the sands were filled by over 6 B brls of oil. This example illustrates three Woodbine sand traps separated only by simple synclines, two of which are oil-bearing, and the other without a trace of hydrocarbons. The principal difference between the three traps is the time of effective closure, and the conclusion that all the Woodbine oil that filled the largest trap on the Gulf Coast was emplaced prior to the middle Eocene is a sound geological deduction. Any geochemical interpretation postulating the location of a Woodbine "kitchen" and time of Woodbine oil expulsion must satisfy the valid timing constraints provided by the absence of oil at *Kelsey* and other, nearby, late traps, such as *Opelika* (Liddle, 1936, p. 55). To suggest that Woodbine oil by-passed, or leaked out of, these traps by some quirk of nature is not geologically convincing.

The *Raudhatain* and *Sabriyah* structures

In Kuwait, the *Raudhatain* and *Sabriyah* anticlines lie side-by-side, separated only by a simple syncline (Fig. 2). Both fields are "super-giants" (Adasani, 1967), with multiple Cretaceous pay-zones; but a major difference exists in the Zubair sand reservoirs which contain large oil reserves at *Raudhatain*, but are water-bearing at *Sabriyah*.

Since no significant faults cut either *Raudhatain* or *Sabriyah*, the absence of Zubair oil in the four-way closure at *Sabriyah* could not realistically be attributed to vertical leakage, or the presence of oil at *Raudhatain* to preferential vertical charging.

In an endeavour to explain this selective charging of adjacent Zubair reservoirs, Al Rawi (1981) analyzed the structural evolution of the two fields by isopach mapping. Isopachs of the Zubair formation showed that a synchronous trap developed during Zubair deposition at *Raudhatain*, whereas at *Sabriyah*, no penecontemporaneous trap development occurred.

The diagenetic evolution of Zubair sands at *Raudhatain* and *Sabriyah* was also shown by Al Rawi (1981) and Khalab *et al.* (1985) to be strikingly different. At *Sabriyah*, authigenic clays are well-developed, whereas at *Raudhatain*, the porosity and permeability of Zubair sands are far superior due to the scarcity of pore-filling authigenic clays, a situation that Al Rawi *(op. cit.)* attributes to the inhibiting effect of early-emplaced oil on the development of authigenic clays.

Trap closure at *Sabriyah* was achieved by active structural growth during the Middle Cretaceous, and although this was sufficiently early to trap large accumulations in Burgan Sand and Mauddud carbonate reservoirs, it was too late for Zubair oil.

The deduction that can be drawn from these petroleum-geological observations is that Lower Cretaceous Zubair Oil was emplaced at *Raudhatain* at least by Ahmadi (Cenomanian) time, when there was less than 2,000 ft (600 m) of overburden on the Zubair formation.

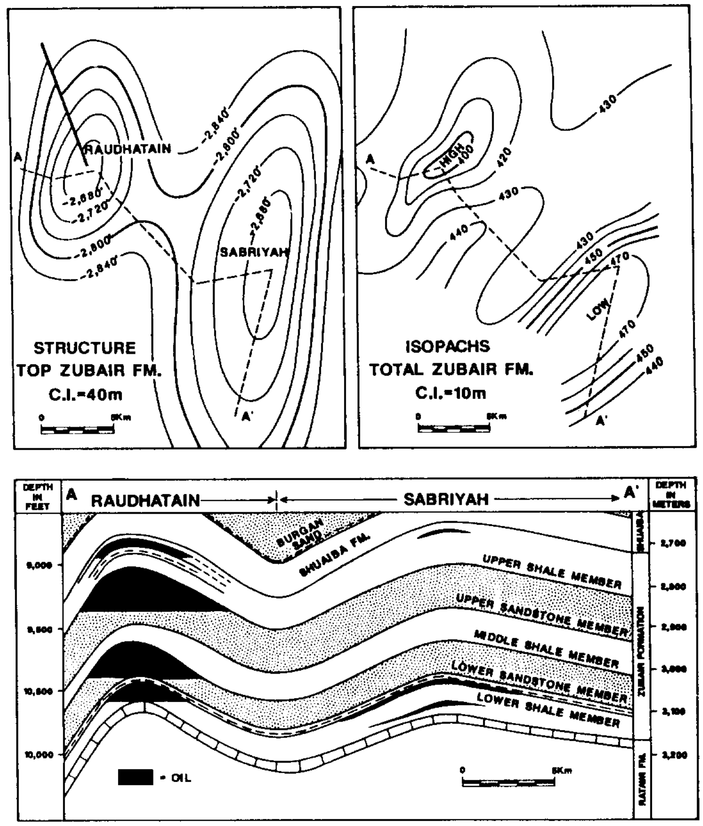


Fig 2.The *Raudhatain* and *Sabriyah* structures, Kuwait, illustrating the relationship of trap timing to hydrocarbon emplacement. The Lower Cretaceous Zubair sands at *Raudhatain* carry large oil columns, whereas the same sands are barren in the adjacent, later *Sabriyah* trap. (After Al Rawi, 1981).

The geological constraints on the time of oil emplacement provided by the selective charging of early traps in the *East Texas - Kelsey* and *Raudhatain - Sabriyah* structural couplets must be included in any deductive interpretations regarding the location and timing of oil generation and expulsion from hydrocarbon sources in both sedimentary basins.

Precise geological studies of the relationship of trap timing to oil occurrence have been used many times in the past to deduce the time of oil migration into traps. For example, Adkins (1956) carried out detailed isopach studies of 200 *East Texas* salt-dome traps, from which he was able to draw the general conclusion that hydrocarbon-bearing traps showed evidence of trap development at least by the time there was 2,000 ft (600 m) of overburden on the productive reservoir, later traps being barren. Isopach studies of structures involving Smackover reservoirs on the Gulf Coast show that if a trap was not present by Lower Buckner time, there is no hydrocarbon accumulation. This is true for paleostructures that have retained structural closure until the present day, as well as those that have lost paleoclosure due to later regional tilt, as at *Walker Creek* (Becher and Moore, 1976, p. 36).

The importance of early trap formation was brought out by observations on barren and productive structures in many basins by Van Tuyl and Parker (1941. Ch.18, p. 124-129).

Many geochemical studies carried out since the early 1960s have concluded that source rocks can be identified only by their richness in organic carbon, and that hydrocarbons can be generated and expelled in economic quantities only when such source rocks are matured by deep burial.

The conflict between geochemical conclusions on catagenic generation of hydrocarbons, and geological conclusions that early migration of oil is necessary to explain the selective charging of synchronous traps, sets up the paradox on time of oil expulsion discussed previously by this Author (Wilson, 1975).

To explain the absence of hydrocarbons in a particular trap, vertical leakage through inadequate cap rocks is frequently called upon as an appropriate explanation. However, despite the occurrence of seepages in many basins, the preservation of large accumulations of oil and gas in Palaeozoic traps, often at very shallow depths, indicates that vertical leakage by seepage through long periods of geological time is not a phenomenon that can adequately explain the absence of accumulations in many well-closed traps.

Anhydrite is accepted as one of the most effective hydrocarbon top-seals, yet, in low-relief Arabian growth structures directly comparable to *Burgan,* the anhydrites that separate "giant" accumulations in stacked Arab Jurassic reservoirs are considered to have leaked, because this is necessary to satisfy the geochemical assumption that all the oil has been generated from the underlying Dhruma formation (Ayres *et al.,* 1982; Wilson, 1982).

Despite the many observations that demonstrate effective containment of "giant" oil and gas accumulations by unimpressive top seals during periods of hundreds of millions of years, the tacit acceptance of vertical leakage to satisfy geochemical postulates is surprising.

The selective filling of early-formed traps, such as those described for the East Texas and Arabian Basins, sets constraints upon the time of oil migration for each productive level. Therefore, in any analysis of hydrocarbon migration in a basin, it is as important to explain the presence of dry traps, as it is that of those bearing hydrocarbons. Without such explanations, a geologically-acceptable interpretation for the timing and pattern of migration cannot be made.

When such analyses have been attempted, for example by Adkins (1956), they have provided persuasive evidence for the early generation and migration of oil and gas.

CONTRASTING DIAGENETIC EVOLUTION AND ROCK COMPACTION WITHIN AND OUTSIDE OIL AND GAS POOLS

It is well-established that porosity and permeability of reservoir rocks deteriorate with increasing burial as a result of compaction, diagenetic changes and cementation. As a result, the migration of oil or gas through reservoir rocks becomes progressively more difficult as burial proceeds. This provides a general constraint on late migration of hydrocarbons along assumed migration paths from "oil kitchens".

Likewise, the weight of empirical evidence from oil- and gasfields around the world provides abundant support for the conclusion that diagenetic processes are inhibited by hydrocarbons. It has also been demonstrated that hydrocarbons, once emplaced in a reservoir, inhibit burial compaction, so that a layer of reservoir rock often exhibits compaction attenuation below the oil-water contact.

The contrast in diagenetic maturity of reservoir rocks within and outside hydrocarbon accumulations was discussed by this Author (Wilson, 1977), and in greater detail by Vinogradov (1979) in support of the general concept of diagenetic entrapment of hydrocarbons. This trapping mechanism was recognized much earlier by Heald (1940, p. 50-60), who described oil and gas accumulations in the Clinton sands of Ohio that are tightly sealed by cementation below the oil-water contact.

Many similar observations of preferential cementation outside hydrocarbon accumulations were noted from different basins by Van Tuyl and Parker (1941).

With the advent of the scanning-electron microscope, more precise observations have been made of diagenetic contrasts across oil-water and gas-water contacts in both carbonate and clastic reservoirs—for example, in the Lower Cretaceous Cadotte sand in British Columbia (Thomas and Miller, 1980).

Petrologists who have documented such diagenetic differences within and below oil and gas accumulations have been faced with the problem of reconciling their petrological observations with the geochemical *dictum* that "oil could have occupied the reservoir only after deep burial of the source rock from which the oil is supposed to have originated". This often requires that the trap also was deeply buried before hydrocarbon entry.

An hypothesis that has gathered popularity portrays the **emanation of aggressive** (acidic) fluids from "oil kitchens" that create porosity in front of the wave of principal oil migration, and in the traps that ultimately are filled with hydrocarbons (Surdam *et al.,* 1985).

Although microscopic observation leaves no doubt that some secondary-porosity creation does occur through chemical reactions in the subsurface, the critical factor that remains to be demonstrated is the connection, if any, between such secondary porosity and the permeability necessary to permit the massive hydrocarbon movements that are postulated. In reality, it is likely that dissolution of minerals to form secondary porosity will result in reprecipitation in pore throats, to cause a reduction in permeability (Johnson and Johnson, 1987, p. 1160).

As is often the case with geological problems, there may be more than one plausible interpretation for observations made; in the instance of porosity contrasts in reservoir rock across a hydrocarbon-water contact, it is important to determine if porosity has been preserved by early emplacement of inhibiting hydrocarbons, or created by much later aggressive fluids, since the implications for timing of hydrocarbon movement are obvious.

For the purposes of this discussion, two examples have been selected in which the data allows the least ambiguous interpretation of time of hydrocarbon movement. These are the *Dalum* field, SW Germany, and fields in the *Ekofisk* area, Norwegian North Sea.

Preservation of aragonite in the *Dalum* oilfield

The *Dalum* oilfield, which lies 30 kms north of Bentheim in SW Germany (Fig. 3), produces from lowermost Cretaceous, Wealden reservoirs on a closed dome. The attenuation of Wealden beds over the structure indicates that a synsedimentary uplift was already present at that time.

A very careful study of the Wealden succession at *Dalum* was made by Fuchtbauer and Goldschmidt (1964), who determined that the aragonite layers of cyrena and gastropod shells that form the *coquina* reservoirs are preserved in the oil reservoir, whereas, in the water leg, they are entirely calcitized.

Fuchtbauer and Goldschmidt (1964, p. 915) concluded that since aragonitic shells become calcite in a few months (at the earliest), or a few dozen millenia (at the latest), oil must have migrated into the highly-permeable aragonitic *coquina* formation very early in the Wealden at *Dalum*. This is entirely conceivable, since the presumed bituminous source rock (in which aragonitic shells also are preserved) is contiguous with the *coquina* on this synsedimentary uplift.

The *Dalum* example confirms the inhibiting effect that hydrocarbons have upon diagenesis, and is particularly important because it implies very early generation and accumulation of oil.

Porosity preservation and inhibition of compaction by hydrocarbons in chalk reservoirs of the *Ekofisk* area

A direct relationship between depth of burial and loss of porosity in chalk was demonstrated from extensive studies by Scholle (1977). From these studies, Scholle was able to show that porosities of over 40% at 9,500 ft (2,900 m) in the *Ekofisk* field chalk reservoir were abnormally high, a circumstance that he attributed to overpressuring in the chalk or to the inhibition of cementation by the early introduction of hydrocarbons.

A later study by D'Heur (1984) of several chalk fields in the *Ekofisk* area showed how porosity decreases down-flank in the chalk reservoirs, as a result of progressive invasion by oil and resulting inhibition of chemical compaction. In the Middle Tor reservoir of the *West Ekofisk* field (Fig. 4), porosities range from 38% in the oil zone to 18% in the water zone (D'Heur, *op. cit.,* p. 221). The same porosity deterioration has been documented for the *East Hod* field, showing how early oil migration is essential for the preservation of oilbearing reservoir quality *(op. cit.,* p. 234). The preservation of porosity and attendant inhibition of compaction by hydrocarbons in these chalk reservoirs results in the flankward attenuation of reservoir horizons, and the preservation of reservoir "thicks" due to differential compaction. This phenomenon is directly comparable to the compactional "thicks", which Dunnington (1967, Fig. 16) demonstrated for Middle East carbonate reservoirs, in which compaction by stylolitization is inhibited by early-emplaced hydrocarbons (Fig. 4). There is no doubt that such compactional lenses, which are common in Middle East oil reservoirs (for example, the *Asab* oilfield in Abu Dhabi: Johnson and Budd, 1975; Mallinson and Sharp 1975; and the *Yibal* oilfield in Oman: Litsey *et al.,* 1983), have often been misinterpreted as organic-sedimentary build-ups, rather than as the result of compactional inhibition by early-emplaced hydrocarbons.

Scholle (1977) suggested that porosity preservation in North Sea chalk reservoirs could be attributed to overpressures prior to oil entry. However, the observation by

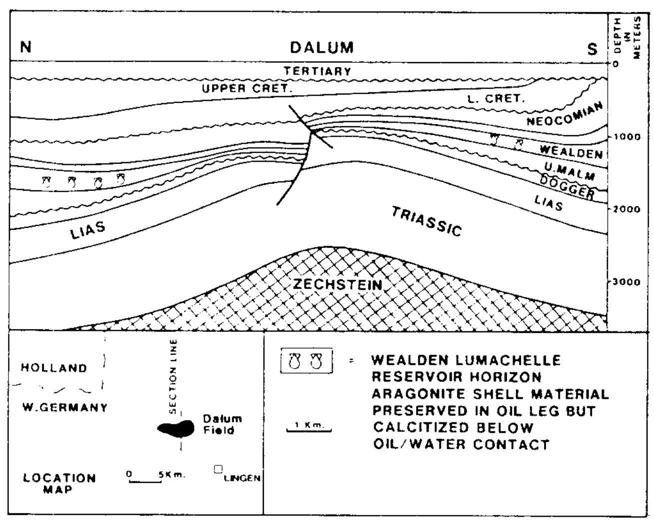


Fig 3. The *Dalum* field, West Germany. In the Wealden lumachelle reservoir, aragonite is preserved in the oil column, but calcitized in the water leg. This illustrates the very early emplacement of oil, which inhibited the diagenetic aleteration of aragonite to calcite. (After Boigk, 1981, Fig. 66).

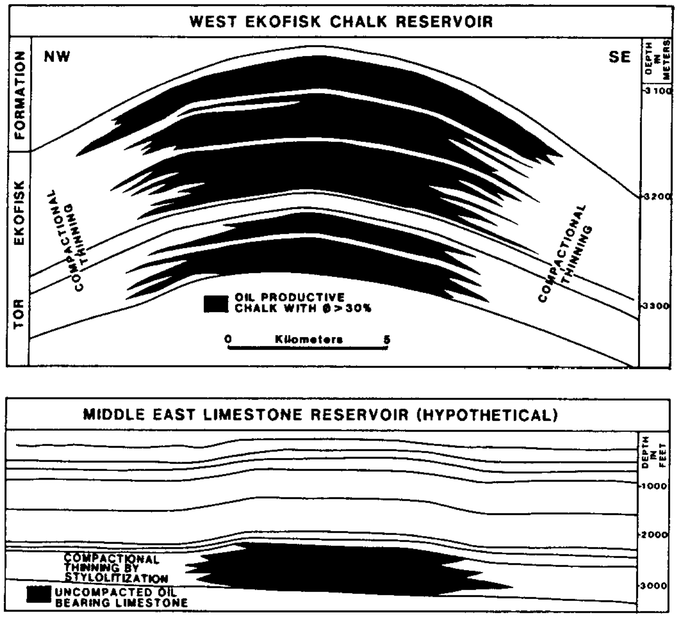


Fig 4.The *West Ekofisk* field, Norwegian North Sea, illustrating how early oil emplacement into the chalk reservoir has preserved porosity and inhibited mechanical compaction of the reservoir. (After D'Heur, 1984, fig. 9). The lower panel is the model of a Middle East limestone reservoir showing Dunnington's (1967) original observation that reservoired oil preserves porosity and inhibits compaction.

Feazel *et al.* (1985, Fig. 31-12 and p. 505) that in the *Ekofisk* area, within the same pressure regime, porosities are preserved in oil-wet chalk, but cemented in the water-wet chalk, suggests that oil alone is responsible for porosity preservation.

With regard to source-rock identification for the Late Cretaceous North Sea chalk reservoirs, the general consensus, based on geochemical criteria, is that the oil has come from mature, Jurassic Kimmeridge clay (Feazel *et al.*, 1985, p. 505). This conclusion sets up vertical migration problems that many geologists find hard to resolve realistically (Chapman, 1983, p. 238). A more harmonious solution would be presented if the North Sea chalk itself was the source rock, in analogy to the petroliferous Senonian chalks of the Gulf Coast and Israel, which provide geochemical evidence for early *in-situ* generation of immature oil (Grabowski, 1981; Conti, 1982; Tannenbaum and Aizenshtat, 1984).

The *Dalum* and *Ekofisk* fields are but two examples from which the diagenetic signatures inside and outside the hydrocarbon reservoirs indicate the early introduction of oil. Many other examples, referenced by Wilson (1977) and Vinogradov (1979), reinforce other geological observations that point to the early charging of clastic and carbonate reservoirs in synchronous traps.

DEFORMED OIL-WATER CONTACTS

Gravity segregation and buoyancy laws dictate that the interface between hydrocarbons and water must be horizontal at the time of accumulation in a trap. If a trap is disturbed by later structural deformation, the oil or gas will readjust to maintain horizontality at the oil-water interface, as long as the permeability of the reservoir rock so permits.

Because of progressive cementation and plugging of porosity by diagenesis in water-saturated reservoir rock, it often happens that hydrocarbons cannot readjust at the water interface. Such a situation can result from general porosity destruction in the water leg, or from preferential cementation in the zone of the oil-water interface itself, as was noted for reservoirs in North America (Van Tuyl and Parker, 1941, p. 62); and, more recently, by Friedman and Sanders (1978, p. 130), and Burley (1986), who recognized preferential ankerite cementation at the oil-water interface in the *Tartan* field, UK North Sea.

Readjustment of hydrocarbons to post-accumulation deformation may also be prevented by the presence of a basal "tar mat", which can effectively seal an oil accumulation at the oil-water contact—for example, at the *McLouth* field in Kansas (Lee and Payne, 1944) and at *Hawkins* in Texas (Wendlandt *et al.*, 1956, p.1847).

In cases where the basal "tar mat" or diagenetic permeability barrier at the oil-water contact is deformed, it is possible to constrain the time of oil emplacement, since the sealing must post-date the emplacement, and the time of deformation can be ascertained by paleostructural reconstruction.

In the Middle East, basal "tar mats" have been identified in many fields. At *Ghawar,* in the Uthmaneya area, the basal Arab "tar mat" is 500-ft (150-m) thick (Mekkawi, 1979, p. 17), and it seems that this substantial seal is responsible for the failure of the Arab accumulations to adjust to the Late Cretaceous NE-ward tilt (Aramco, 1959, p. 449), rather than to any hydrodynamic forces.

In the *Fereidoon* field, offshore Iran, a basal "tar mat" has prevented the Lower Cretaceous *Yamama* pool from adjusting to the Miocene easterly tilt (Kaveh *et al.,* 1971, p. 135).

In the *Minagish* field, Kuwait, and the *El Bunduq* field, Qatar, basal "tar mats" in the Lower Cretaceous Minagish oolite and Jurassic Arab D dolomite, respectively, are folded (El-Aouar and Rasool, 1970; Bashbush et *al.*, 1983).

The *El Bunduq* field (Fig. 5)

By paleostructural analysis, it has been shown that the "tar mat" in the Arab D reservoir at *El Bunduq* was horizontal at Mishrif (Middle Cretaceous) time, and since 70% of the Arab D oil is reservoired above the folded "tar mat", indications are that the main migration and accumulation of Arab oil had taken place before Mishrif time (Bashbush *et al.,* 1983, p. 325). The Arab D dolomite reservoir attenuates from 325 ft (98 m) on the crest to 250 ft (75 m) on the flanks of *El Bunduq,* pointing, once again, to compactional inhibition by reservoired hydrocarbons.

Deformed oil-water contacts in the San Joaquin Basin, California

In the San Joaquin Basin, California (Fig. 6), the diagenetic sealing of Eocene Gatchell Sand reservoirs in the *East Coalinga. Pleasant Valley* and *Guijarral Hills* fields on the east-plunging Coalinga nose is well-documented (Weddle, 1951; Schneeflock, 1978).

The permeability barriers that separate Gatchell sand production in the *Pleasant Valley* field from up-dip production in the *East Coalinga* extension field and down-dip production in the *Guijarral Hills* field are due to plugging of porosity and permeability by authigenic kaolinite.

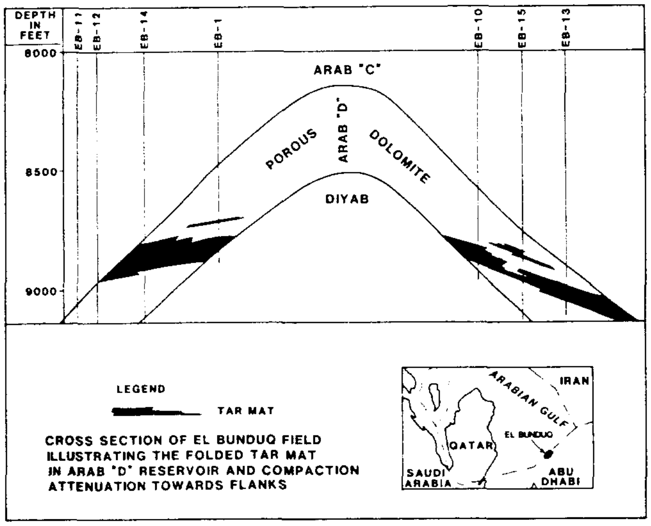


Fig 5.The *El Bunduq* field, offshore Qatar/Abu Dhabi, illustrating the folded, basal "tar mat" in the Arab D (Jurassic) dolomite reservoir. Since folding of the "tar mat" post-dates oil emplacement, the time of oil accumulation must have predated all the folding that has occurred since the mat was horizontal. (After Bashbush, 1983).

Published subsurface sections across these fields running NW-SE (Harding, 1976, Fig. 9) and east-west (Chambers, 1943; Church and Krammes, 1957) indicate, by thickness changes in the Kreyenhagen shale, that all three fields had some westerly paleostructural reversal immediately following the deposition of the Gatchell sandstone. These reversals, on what appear to be north-south oriented paleostructures, were rotated-out successively by pre-Temblor, pre-Etchegoin and post-Tulare deformations. Since primary porosity and permeability in the Gatchell sand have been retained by the inhibiting effect of hydrocarbons on the authigenic degradation of feldspar grains to kaolinite (Schneeflock, *op. cit.*, p. 852), and because paleostructural traps capable of focussing the present accumulations appear to have lost closure soon after deposition of the Kreyenhagen source rock, it is logical to conclude that oil emplacement took place very soon after Gatchell deposition, and that these accumulations were diagenetically sealed very early.

The propensity of immature arkosic sands to react to early diagenetic changes is well known, not least from experiences of reservoir damage by drilling fluids.

The Upper Miocene Stevens sands are medium- to coarse-grained arkosic sandstones, that were probably derived from the Sierra Nevada granodiorite and deposited as deepwater fans (Boles and Ramseyer, 1987, p. 1476). The Stevens is an important oil reservoir in the *Elk Hills, North* and *South Coles Levee* and *Paloma* fields, which are of special interest because of tilted and folded oil-water contacts in the Stevens reservoirs. The *Paloma* Stevens accumulation is offset to the NE of present-day closure, with the oil-water contact tilted in that direction. The SW limit of the field is defined by tight Stevens sand, that loses permeability by addition of clay and silt (Simonson, 1959, p. 103 and Figs. 4 and 5). The *North* and *South Coles Levee* fields are on present-day plunging noses, with oilwater

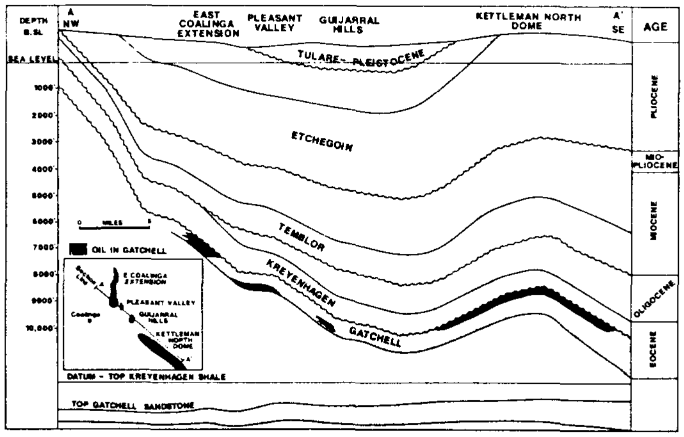


Fig 6.The *Pleasant Valley, Guijarral Hills* and *East Coalinga* field, San Joaquin Basin, California, illustrating diagenetic traps in the Eocene Gatchell sandstone. The lower panel shows paleostructure on the top-Gatchell horizon at end-Kreyenhagen time. It is suggested that the kaolinite permeability barriers in the Gatchell sandstone followed oil emplacement during Kreyenhagen time. (After Harding, 1976, Fig. 9).

contacts tilted strongly to the east, with up-dip closure achieved by loss of permeability in the Stevens sand. This permeability barrier is the only separation between the *North Coles Levee* accumulation and *Elk Hills,* which lies up-dip on the same structural axis and also has an oil-water contact tilted to the east.

Detailed subsurface sections across the axes of *Elk Hills* (Lorshbough, 1967) and *North Coles Levee* (Davis, 1952; Hardoin, 1962) show clearly that both oil-water contacts in the Stevens reservoirs are folded (Fig. 7).

An isopach map of the Pliocene Etchegoin formation over the *Elk Hills* and *North Coles Levee* fields (Maher *et al.,* 1975) indicates Pliocene paleostructural containment of the fields, with horizontal oil-water contacts, and shows that, at that time, the tight wells in the permeability barrier that now separates *Elk Hills* from *North Coles Levee* lay in a Pliocene paleostructural saddle, below the paleo oil-water contact (Fig. 8).

Cross-sections also clearly indicate, by crestal attenuation of pre-Etchegoin beds, that paleostructural formation commenced immediately after Stevens deposition.

The reservoir drive-mechanism at *North Coles Levee* was by gas-cap expansion during the first four years of production, before gas injection commenced, and no movement of the oil-water contact was noted (Davis, *op. cit.,* p. 13). That this is a depletion-type reservoir is further supported by observed drop-off in permeability towards the paleo-flanks, and greatly improved porosity and permeability over the paleo-crest (Davis *op. cit.,* p. 12).

The tilt and amplitude of folding of the oil-water interface at *North Coles Levee* and *Elk Hills* conforms closely to present-day top-Etchegoin structure, which leads to the conclusion that Stevens oil was locked in-place by that time, and could not adjust to the post-Etchegoin structural overprint.

Given the described reservoir conditions, it is unrealistic to attribute the tilted and deformed oil-water contacts at *North*

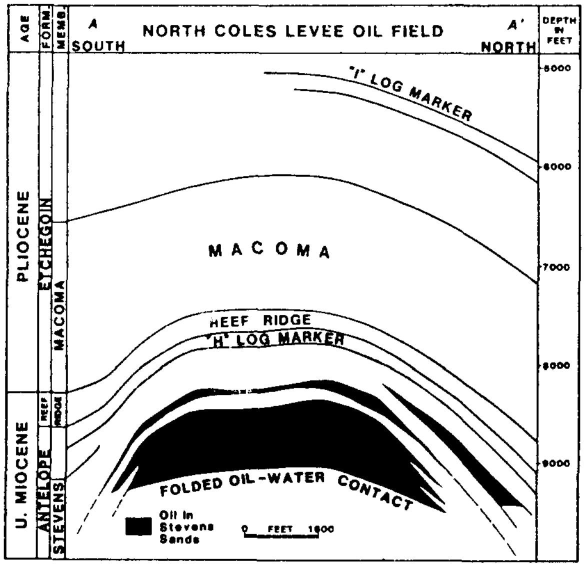


Fig 7. The *North Coles Levee* field, San Joaquin Basin, California, illustrating the folded oil-water contact in the Upper Miocene Stevens sand reservoir. This srggests that Stevens oil had accumulated before the end of Pliocene time. (After Hardoin, 1963, Plate V).

and *South Coles Levee* fields to hydrodynamics, as concluded by Dahlberg (1982, p. 117). It also seems most unlikely that oil was emplaced into a deformed porosity pod during the Pleistocene, as interpreted from studies of complex cement chemistry by Boles and Ramseyer (1988, p. 1485).

Since the Monterrey is such a richly-petroliferous formation, it is reasonable to assume indigenous sourcing of the Stevens sand. Indications are that Stevens oil was generated early, and this is corroborated by evidence for early Monterrey oil generation (Peterson and Hickey, 1984).

Regardless of oil source, the foregoing examples from the Middle East and California show how deformed oil-water contacts can be used to constrain the time of oil entrapment, which can then be applied to test general concepts about the time and duration of oil generation and migration in a basin.

THE ORIGIN OF HEAVY-OIL AND "TAR" BELTS

Deposits of heavy-oil and "tar" around the world occur in volumes that far exceed known reserves of conventional oils (Rodifer, 1987).

It is imperative, therefore, that any comprehensive investigation of the formation of liquid hydrocarbons should adequately explain the mode of generation and accumulation of these huge deposits.

The existence of heavy-oil accumulations is due, according to Connan and Van der Weide (1974, p. 134), to either one of two causes, or to a combination of them:

First, they might be immature primary crudes—that is to say, crudes that have not been exposed to adequate temperatures and pressures; secondly, heavy-oil may result

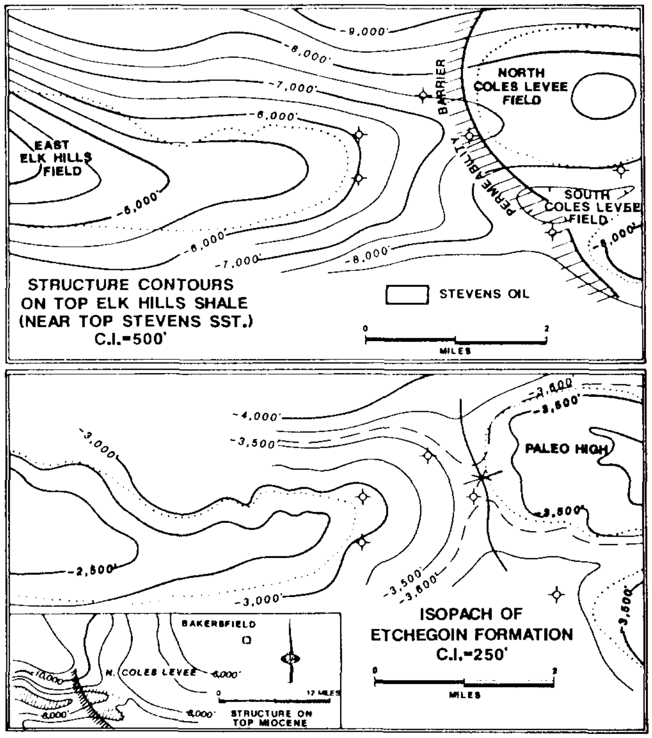


Fig 8. The *North Coles Levee* and *East Elk Hills* fields, San Joaquin Basin, California, illustrating, in the upper panel, the permeability barrier that prevents Stevens oil in the *North Coles Levee* field from migrating up present-day dip into the *East Elk Hills* field. The paleostructure illustrated by the isopach of the Etchegoin formation shows that the two accumulations were structurally separated at that time. The permeability barrier is probably due to diagenetic plugging of Stevens sands after oil accumulation, as suggested by the folded oil-water contact (Fig. 7). (After Maher *et al.*, 1975).

from the contact of normal (mature) oils with meteoric waters, which are thought to bring about a more-or-less severe alteration, entailing the removal of the higher, more soluble oil components, as well as bacterial degradation which, *inter alia* removes low-ring napthenes and aromatics and forms asphaltenes. In addition, the oil frequently becomes enriched in sulphur compounds, a phenomenon tentatively ascribed to the action of sulphate-reducing bacteria.

When interpreting the mode of origin of a heavy-oil deposit, it is important to remember that bacterially-degraded oils frequently resemble immature, unaltered oils in their physical properties, their gross composition, and their sulphur content (Connan and Van der Weide, 1974, p. 135). The signifcance of this similarity, which has a direct bearing upon interpretations of the formation of the world's largest hydrocarbon deposits, has been insufficiently stressed in geochemical literature. As a result, the majority of published interpretations of the origin of huge heavy-oil and "tar" accumulations conclude that these hydrocarbons were emplaced as mature oil, and, at some later date, were altered to heavy-oil by biodegradation and/or water washing.

The process of biodegradation, as the main cause of alteration of mature oils to heavy, asphaltic oil, was supported by *in vitro* experiments (Bailey *et al.*, 1973), in which crude oils were exposed to bacteria under laboratory conditions. Extrapolating from these laboratory experiments, it is now generally assumed that biodegradation will occur **whenever** a mature oil accumulation is in proximity to meteoric formation waters, which are thought to carry oxygen and micro-organisms into contact with the oil at the oil-water interface. As a corollary, it has been assumed that biodegraded oils will accompany low-salinity (meteoric) waters in shallow basin flank positions (Tissot and Welte, 1978, p. 415). Considerable doubt has been cast on this general assumption by a recent study of Tertiary sand reservoirs in Niger Delta fields, where it was demonstrated that unaltered oils occur in sands with meteoric water, and biodegraded oils occur in sands with connate waters (Dickey et *al.,* 1987, p. 1326).

Although most heavy oils do occur at shallow depths, it is difficult to account for their general degradation by bacteria, since the micro-organisms come into contact with the deposit only at the oil-water interface. This results in the formation of a "tar mat", which then seals the oil from further degradation. It is also noteworthy that large accumulations of mature oil have remained unaltered in many basins, despite long residence at very shallow depths. In West Virginia, for example, many millions of barrels of high-grade oil have been produced from depths of only 100-200 ft (30-60 m) (Price, 1972), and "giant", shallow fields (such as *Bradford)* have not suffered degradation.

In the Oficina area of Eastern Venezuela, the *West Guara* field has 25 "pays" at relatively shallow depths, with API values ranging from 11°-49°. The lighter oils occur above heavier oils, and water salinities in this region are typically very low (Renz *et al*., 1958, p. 587-591).

With so many evident exceptions to the assumed rules that govern bacterial degradation, a measure of doubt regarding the importance of this process in Nature is scientifically justifiable, not least because the fate of the microbial cell material with respect to the composition of biodegraded crude oil is unclear (Tissot and Welte, 1978, p. 414).

The generation of immature oils is accepted by many geochemists, although it has been rated of little economic importance.

Hunt (1987, p. 345) maintains that a few heavy-oils form directly from organic-rich source rocks of early maturity. Leythaeuser (1987, p. 341) holds that certain heavy-oils (called "primary") are generated and released at relatively shallow depths and low maturity levels from source rocks of special lithology and kerogen type, a view that is strongly supported by the work of Peterson and Hickey (1987) on the Neogene heavy-oils of California.*

Connan and Coustau (1987, p. 265) mention the 500-600 MM tons of marginally-mature oil in the *Emeraude* field, Congo Republic, and the immature- to marginally-mature oils of the *Maria A. Mare, Sarago Mare* and *Mornmora Mare* fields in the Adriatic, offshore Italy (*op. cit.,* 275).

Tissot and Welte (1978, p. 400) advise that, at shallow depths, during the phase of diagenesis, the source rock is immature, and the available hydrocarbons and associated molecules are, in most cases, more or less directly inherited from living organisms ("geochemical fossils"). They conclude that the abundance of these hydrocarbons is generally too small to provide commercial accumulations, but that these, together with small amounts of hetero-atomic compounds, may form some accumulations of heavy-oils.

In-reservoir maturation of oil, or "natural cracking" in response to increasing burial temperatures and pressures, is an accepted process. With increasing burial and temperatures, oil accumulations become specifically lighter, and contain an increasing amount of low molecular weight hydrocarbons at the expense of high molecular weight constituents (Tissot and Welte, 1978, p. 410; Hunt, 1979, p. 405).

An important uncertainty that has attracted sparse comment is whether a pool of mature oil has been formed by in-reservoir maturation of an originally-immature oil, such as that at *Emeraude;* or whether the mature oil is the product of late (catagenic) expulsion from a mature source rock. The latter process is the generally-accepted explanation for economic accumulations of mature oil, but if heavy, immature oils are more abundant than is currently believed, then the former process must be very important.

For this reason, it becomes imperative to understand the dominant process responsible for huge heavy-oil and "tar" deposits. To do this, the logical subject for analysis is the much-studied *Athabasca* heavy-oil and "tar" belt of Canada. where, according to Rodifer (1987, Fig. 8), the in-place reserve is 1.35 T brls, and interpretations of its time of generation are controversial (Stewart and MacCallum, 1978).

The *Athabasca* heavy-oil and "tar" belt (Fig. 9)

In his analysis of Lower Cretaceous oil and gas in Western Canada, Masters (1984), following the views previously

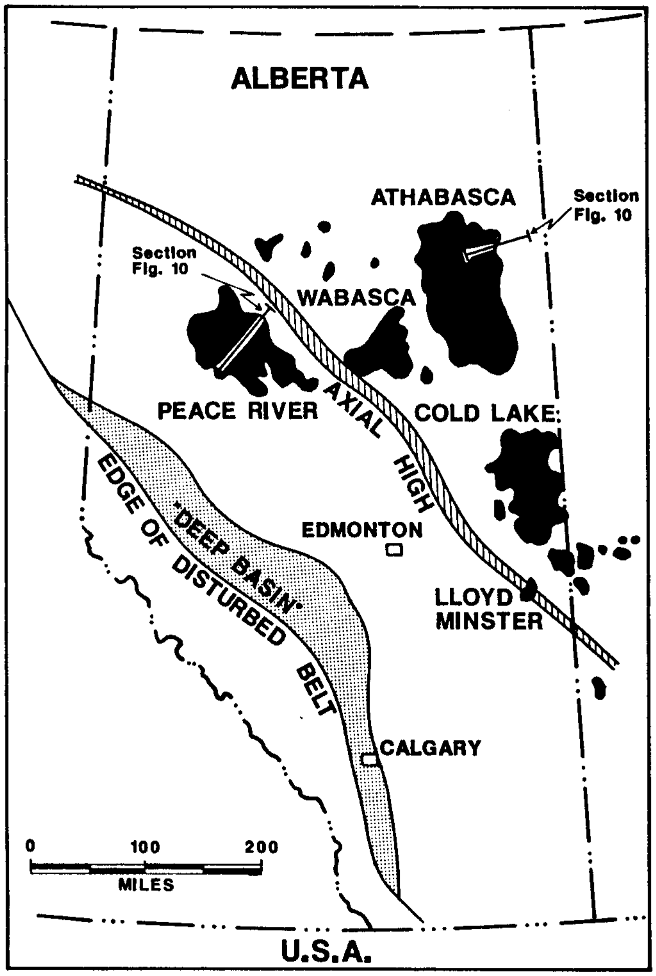


Fig 9.The *Athabasca* "tar" and heavy-oil belt, showing the location of subsurface sections (Fig. 10).

expressed by Deroo *et al.* (1977), concludes that the huge reserves of heavy, sulphurous, oils and bitumen in the *Athabasca* region were generated from thermally-mature Lower Cretaceous sediments in the deep Cretaceous-Tertiary basin to the west. These oils migrated NE-ward some 250 miles (400 kms) at end-Cretaceous-Early Tertiary time, to accumulate in the *Athabasca* anticline and other structural and stratigraphic traps towards the basin margin.

Subsequently, the trapped, mature oils were altered to heavy-oils and bitumens by water-washing and biodegradation, when erosion brought the reservoirs into contact with meteoric water. This prolific generation from the Cretaceous "oil kitchen" was followed, according to Masters (1984), acceding to the views of Welte *et al.* (1984), by a phenomenal generation of gas from the Cretaceous "gas furnace" (Masters *op. cit*, p. 26) which commenced in the early Oligocene and is still continuing today.

A more recent opinion on the origin of the *Athabasca* heavy-oils, based on the study of biomarkers, was provided by Brooks and Macqueen (1987), who stated that all organic geochemical studies, including their own, had demonstrated that the heavy-oils and bitumens were *conventional (mature)* oils before alteration. This is an unfortunate statement, because several important organic-geochemical studies have concluded, quite to the contrary, that the heavy-oils and bitumens are *immature* hydrocarbons. Vigrass (1968, p. 1995) referred to several early chemical studies, from which it was concluded that the Lower Cretaceous heavy-oils were immature; since this time, the results of more refined organic-geochemical studies have been published (Montgomery *et al.*, 1974; Montgomery, 1974; George *et al.*, 1977; Samman *et al.*, 1981; Payzant *et al.*, 1986; Cornelius, 1987, p. 169), all of which concluded that the *Athabasca* "tars" and heavy-oils are *immature.* Keeping the latter views in mind, and particularly the spirited exchange of opinion between Montgomery and Deroo (Hills, 1974), it must be concluded that organic-geochemical data alone do not allow a unique interpretation for the mode of generation and emplacement of these enormously-important hydrocarbon accumulations.

Since opinions are divided amongst geochemists on the resolution of what is recognized to be a very complex problem (Paxson, 1987, p. 160), it is essential to review the great wealth of data from other branches of geology, collected since Ells' pioneer survey in 1926. In this way, it should be possible to ascertain which of the two geochemical interpretations best fits into an integrated petroleum-geological synthesis.

Original overburden, structural attitudes and oil-migration problems

The outcrop pattern of *Athabasca* "tar sands" and succeeding Mesozoic and Tertiary formations is the result of erosional back-cutting of the eastern, foreland flank of the Cretaceous-Tertiary basin, following uplift and tilting that accompanied Laramide (Eocene) and post-Laramide movements. SW tilting during the Tertiary was followed by the removal of several hundred metres of Cretaceous strata (Mossop, 1980, p. 148). The maximum depth of burial of Lower Mannville sediments in the *Athabasca* area, based on coal-rank measurements of V_4 (0.4 R_o) was estimated by Deroo *et al.* (1977, p. 7) to be less than 4,000 ft (1,200 m), a figure that is not inconsistent with estimates obtainable by structural restoration.

The present-day regional SW dip of Cretaceous strata across the *Athabasca* area is from 3 to 5 ft per mile (Carrigy, 1971, p. 1158), a gradient that Roberts (1987, p. 461) claims would be totally ineffective for migration of oil by buoyancy.

Deroo *et al.*, (1977, p. 111) claim that geological conditions presented no obstacle to migration of fluids from the deep parts of the basin to the basin margin at the time of the Laramide orogeny. What seems to have been overlooked is that the time of maximum Laramide movement and concomitant regional tilting was during the Eocene (Deroo *et al.*, *op. cit.*, p. 6), whereas the time proposed for the principal phase of oil generation was Late Cretaceous (Deroo *et al.*, *op. cit.*, p. 110), when there was no regional SW dip, and an axial high (Jackson, 1984, p. 52) formed a barrier between the *Athabasca* area and the developing foredeep. If we assume that normal oils were emplaced by long-distance migration, it needs to be explained why the *Athabasca* oils did not move up-dip when the paleoclosure at *Athabasca* was lost through regional tilting, yet the basin margin still lay far to the east of present-day outcrops.

Nature of McMurray sand, diagnesis and preservation of fossil wood.

The environments of deposition of the Lower Cretaceous Mannville sediments have been well-described by Carrigy (1971) and Jackson (1984). The *Athabasca* "tar sands" were laid down on a mature erosional landscape in a fluvio-deltaic environment. The paludal-lagoonal deposits that followed in the Upper Mannville were finally transgressed from the north by open-marine Clearwater Shales. These sediments, which display typical facies discontinuities, were draped over a large north-south trending paleotopographic swell (Carrigy, 1971, p. 1157, Fig. 2).

The loose nature of the bitumen-impregnated McMurray sands was first noted by Ells (1926, p. 46), who observed that the lower sands were apparently uncompacted prior to impregnation by bitumen, as was borne out by the instability of fresh bituminous sands that were intersected in mining shafts (Ells *op. cit.*, p. 56). Later, Ball (1935, p. 159) remarked that on removal of the oil, only a loose, sugary sand remains. Allen (in Sproule, 1938, p. 115) observed that the bituminous McMurray sands are loose sand grains held together with petroliferous material, from which he deduced that the oil had been introduced before sufficient time had elapsed for the sand to change to sandstone.

Porosities in the *Athabasca* "tar sands" are as high as 35% because of the lack of mineral cement (Mossop, 1980). These observations are confirmed by Scott (1987, p. 437), who adds that the major bitumen deposits in Canada and Venezuela are found in entirely uncemented sands.

The many geological reasons for concluding that the McMurray oils were emplaced early from indigenous sources were succinctly presented by Corbett (1955), who viewed these deposits as oilfields "in a state of arrested (immature) development".

The absence of cement, and the unconsolidated nature of the McMurray "tar sands", is difficult to explain if we accept the hypothesis of Deroo *et al.* (1977), that the sands had been subjected to diagenetic reactions for at least 40 MM years and geostatic pressures under some 4,000 ft (1,200 m) of overburden before oil entry in Late Cretaceous-Early Tertiary time. The absence of compaction and cementation in the bitumen-impregnated sands must also be related to the interlocking grain contacts, quartz overgrowths and pressure-solution effects that have reduced porosity in barren McMurray sands (Barnes and Dusseault, 1982). Differences in diagenetic evolution within and outside heavy-oil accumulations adjacent to *Athabasca* also have been observed. In the Grand Rapids formation of *Wabasca* the barren sands contain a significantly higher percentage of montmorillonite than in oil-bearing zones, where the hydrocarbons are thought to have inhibited the development

Organic-geochemical data alone do not allow a unique interpretation for the mode of generation and emplacement of hydrocarbons.

of authigenic clays (Kramers, 1974, p. 81). Likewise, in the Upper Grand Rapids sands at *Lloydminster,* the permeabilities in the water-wet sands are much lower than in the oil zone, due to the development of sericite, siderite and quartz cements-diagenetic developments that have been inhibited in the oil zone (Orr *et al.,* 1978, p. 82), where the sands are uncemented (Smith, 1986, p. 29). Also, in the *Peace River* heavy-oil deposit, the developments of kaolinite and montmorillonite cements are markedly higher in the water zone of the Gething (McMurray) heavy-oil reservoir (Rottenfusser, 1982). All these relationships provide timing constraints on hydrocarbon occupancy of reservoir sands, because it is reasonable to suppose that much of the diagenesis took place during maximum burial rather than during post-regional tilt offloading.

The occurrence of exceptionally well-preserved fossil wood in the *Athabasca* "tar sands" was first recorded by Ells (1926 p. 55), who observed that whereas the wood fragments that were not enveloped by bitumen were partly or wholly carbonized, those that are insulated by petroleum appear to have undergone very little alteration. Ells concluded that the wood must have been enveloped by petroleum very soon after deposition. Sproule (1938, p. 1137) also noted that where the fossil tree-trunks occur in impregnated beds, the wood is so well-preserved that the delicate cell structure remains intact, even though freshly-mined pieces are as soft as cheese. Sproule *(op. cit.)* also attributes this preservation to the enveloping hydrocarbons, which he presumes were emplaced during or immediately-after the deposition of the sediments. Although Carrigy (1971, p. 1167) records the occurrence of "mummified" logs in the pre-deltaic facies of the Lower Manville, there appears to have been no further research into the reason for such remarkable preservation of organic structure. The well-known preservation of Pleistocene fossils by entombment in bitumen at *Rancho La Brea,* California (Stock, 1972), and the preservation of plant material in Iranian natural bitumens (Goodarzi, 1984) are relevant to the interpretation of *Athabasca* wood preservation. Unless some other scientific explanation can be provided, the inhibiting effect on diagenesis by very early oil emplacement, as in the case of aragonite preservation in the Wealden lumachelles at *Dalum,* previously described, is an explanation that must be seriously entertained. Further research into the reasons for preservation of fossil wood, which could be extended to include examination of freshwater mollusca in bitumen beds (Ells, 1926, p. 34), which, according to G. M. Friedman *(personal communication)* contain aragonitic specimens, might provide valuable new insights on the time of hydrocarbon emplacement.

Tilted oil-water contacts (Fig. 10)

The westerly tilt of the oil-water contact at *Athabasca* (Fig. 10) was first described by Ells (1926, p. 16), and thereafter by Mossop (1980, p. 149), and illustrated in cross-section by Jardine (1974, Fig. 10). The bitumen-free *Athabasca* sands to the east and up-dip from this oil-water contact were observed by Ells (1926, p. 16) and confirmed by

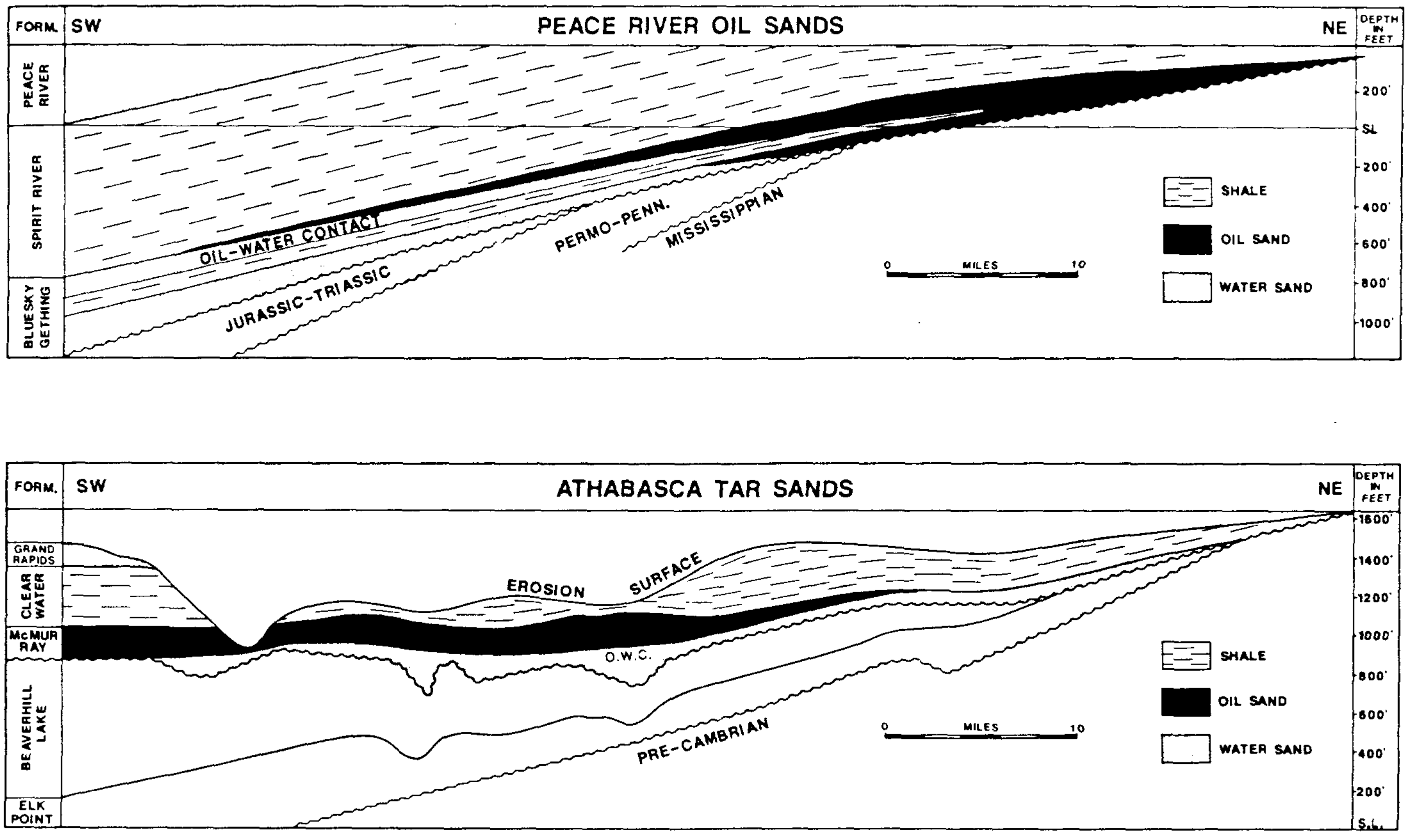


Fig 10.Subsurface sections across the *Athabasca* "tar" deposit and *Peace River* heavy-oil field, illustrating the tilted oil-water contacts that conform to regional dip. This suggests that the hydrocarbons accumulated before the regional tilt was imposed. (Section locations on Fig. 9). (After Jardine, 1974).

Jardine (1974, p. 58) and many others.

West- or SW-tilted oil-water contacts are also present in the *Wabasca* heavy-oil area (Jardine, 1974, p. 56), where Kramers (1976, p.74) suggests that structural contours do not outline the oil deposit, because accumulation over paleodrape closures preceeded regional tilting to the SW, and the oil has been unable to adjust.

In the *Lloydminster-Bonnyville* heavy-oil area, many accumulations are on noses and structural terraces, possibly because of diagenetic plugging in the water leg of paleostructures prior to regional tilt (Vigrass, 1968, p. 1993; Orr *et al.*, 1978, p. 82).

On the structural cross-sections of Jardine (1973, p. 55, Fig. 6), a westerly tilt is clearly shown on the oil-water contact in the Bluesky-Gething reservoir of the *Peace River* deposit, and this same tilt direction holds true for the oil-water contact in the Upper Grand Rapids reservoir at *Cold Lake* (Matheny, 1979, p. 109, Fig. 2).

The observed west to SW tilts of oil-water contacts in the *Athabasca* heavy-oil region conform with the regional dip that was imposed in Tertiary time. If it is assumed that these oil-water contacts were originally horizontal, then it follows that oil accumulation preceded the imposition of regional SW dip. The tilting of oil-water interfaces could not be attributed to hydrodynamics, because, according to Deroo *et al.* (1977, p. 7), the fluid flow is in the opposite direction.

The foregoing geological observations from the *Athabasca* heavy-oil and "tar" belt all provide support for the early introduction of oil into these reservoirs. If oil migration started in the Late Cretaceous from the Rocky Mountain foredeep, the migration pathways proposed by Deroo *et al.* (1977) would not only have lacked the necessary gradient for movement, but must also have traversed the axial high that separated the foredeep from *Athabasca* (Jackson, 1984).

Diagenetic contrasts between oil- and water-bearing reservoir rocks, the tilt of oil-water contacts, and the presence of bitumen-impregnated, "mummified" wood and aragonitic mollusca all support the deductions of the pioneer geologists, that these heavy hydrocarbons are immature, and were trapped early during Lower Cretaceous time in Lower Cretaceous paleostructures. For this reason, the, geochemical deduction that large concentrations of bicyclic and tetracyclic terpenoid sulphides in the *Athabasca* bitumen is evidence that it has never been exposed to conditions of severe geothermal maturation (Payzant *et al.*, 1986) is in harmony with geological observations. In fact, the geological observations suggest, as was concluded by Ells (1926, p. 55) and Sproule (1938, p. 1137), that the oil was emplaced close to the time of sedimentation, a suggestion that runs completely counter to the interpretation that the huge deposits of heavy-oil and "tar" in the *Athabasca* region are the biodegraded residue of mature oils sourced in a Cretaceous-Tertiary "kitchen" to the SW.

Considering the Deep Basin Elmworth gas province (Masters, 1984), whence the heavy-oils are supposed to have come, it is notable that the gas-bearing Cretaceous sands are generally tight, and that for economic "deliverability" it is important to encounter "sweet spots" which have higher porosities and permeabilities (Masters, *op. cit.*, p. 26). It seems that such "sweet spots" might relate to paleostructures where early introduction of hydrocarbons has prevented porosity destruction by burial diagenesis. This is implied from SEM studies by Thomas and Miller (1980) of Cretaceous reservoirs in this region, and also by paleostructural development in the Elmworth area, that is implied by stratigraphic thinning towards the *Elmworth* field (Masters, 1979, p. 162, Fig. 8). The presence of pyrobitumen in some Deep Basin reservoirs (Masters 1984, p. 27) is also significant, since it implies that at least some of the gas has resulted from in-reservoir cracking of earlier oil accumulations. Late, thermal generation of gas has surely occurred in the Deep Basin, but, as is so frequently the case, the late-generated hydrocarbons were unable to move because permeabilities have been so severely reduced by compaction and diagenesis.

After considerable study of the *Athabasca* oil, Ball (1941) noted its sensitivity to heat, which explained why such a complete line of products could be made from such a heavy, tarry material. He pointed out the differences between this virgin (immature) oil and residual (degraded) oils that are usually refractory and insensitive to heat. These early conclusions regarding contrasts in temperature reactions between immature and degraded, mature heavy-oils are closely comparable to experimental results obtained much later by Connan (1972) on heavy-oils from France and Switzerland.

This review of structural, stratigraphic, petrologic and oil habitat data garnered from literature on the *Athabasca* heavy-oil belt greatly favours those geochemical interpretations that categorize the oils as immature. If these huge volumes of hydrocarbons can justly be placed into Orton's (1888) category of "generation by organic decomposition at low temperatures", then this becomes the dominant mode of formation of the Earth's known liquid hydrocarbons, and raises a chain of ancillary questions regarding sourcing, migration and accumulation of heavy, immature oils.

IMMATURE OIL AND THE QUESTION OF BIOGENIC GENERATION

The generation of immature oil as an actual process in Nature seems no longer to be in question, and although some geochemists maintain that it is unimportant, others describe examples of significant oil generation (Petersen and Hickey, 1987; Connan and Coustau, 1987). The generation of immature oil together with immature gas has been reported from the Gulf of Mexico (Hunt, in Welte *et al.*, 1980, p. 49), and immature condensate has been recognized from Canada, Trinidad and East Asia (Stahl, in Welte *et al.*, 1980, p. 50).

Convergence of evidence is bringing the accepted process of "biogenic" gas generation ever closer to significant low-temperature generation of oil-, which then raises the important question, emphasized by Zhang Yi Gang (1981) and Roach (1987), of "biogenic" oil generation.

Organic-geochemical studies show how important is the role of bacteria in early diagenesis of organic matter in sediments. The role of bacteria in transformation of organic matter in sediments was recognized early-on by Zobell (1945), and researched more recently by Tornabene (1981) and Orisson *et al.* (1984). The probable presence of "mats" of sulphur-oxidizing bacteria is thought to have had an important influence on the generation of immature Monterrey oils (Isaacs, 1987), and the high concentration of bacterio-hopanes in Adriatic immature oils, as well as oils generated in evaporitic environments, indicates that bacteria have been significant in the parent source (Connan and Coustau, 1987, p. 276).

It seems that bacteria, rather than being the principal agents in the *destruction* of oil pools by biodegradation, may, on the contrary, be the principal agents in the *formation* of "proto-oil" and immature oil.

If, as suggested here, the early presence of oil is responsible for the inhibition of diagenesis, cementation and compaction in oil reservoirs, then very early oil emplacement, and by inference generation, is a necessary corollary.

The earliest-generated oil is likely to be a sluggish asphaltic and sulphurous liquid, such as that described from the Messinian evaporites of Sicily by Warren (1986).

The heavy, sulphurous, Pliocene oil of the *Rozel Point* and *West Rozel Point* fields in the Great Salt Lake, Utah, is considered by some geochemists to be extremely immature (N. Petersen, *personal communication),* and Hunt (1979, p. 146); yet others have interpreted it as a biodegraded, mature oil (Bortz, 1987, p. 562). It would be important to resolve this difference of opinion, since the estimated in-place reserves of over 100 MM brls at a depth of 2,200 ft (660 m) cannot be considered as insignificant generation. Bortz (1987, p. 557) considers the dark, anhydritic, organic shales of the Pliocene to be the source for this 4-9° API, high pour-point, high-sulphur (12-13%) oil. However, the Pliocene, as illustrated (Bortz *op. cit.*, Fig. 2) does not attain any great thickness, and seems to be too shallow to have reached maturity. The *West Rozel Point* oil may well be in a state of immaturity that is closely comparable to that in the Canadian heavy-oil fields, and, as suggested earlier (Wilson, 1975, p. 82), the black organic clays and associated evaporitic sediments of the Great Salt Lake seem to offer a prime opportunity for further research into the problems of early oil generation and migration.

The generation of heavy, immature oils in large volumes, for example, the heavy Miocene oils of the Adriatic (Connan and Coustau, 1987, p. 276), introduces further problems into the "enigma" of primary and secondary migration, since a mechanism must be found capable of moving large, immature hydrocarbon molecules out of source rocks and along secondary migration paths. The physical problems thus presented make indigenous sourcing more likely, and long-range, vertical or horizontal transport improbable.

In the *Athabasca* area, methane was frequently encountered in early wells drilled into the McMurray Tar Sands (Ells, 1926; Carrigy, 1971, p. 1158). In the *Lloydminster* heavy-oil fields, methane is present as gas caps and in solution with the heavy-oils, which produce by solution gas-drive from reservoirs of unconsolidated Mannville sands below 1,800 ft (540 m) (Smith, 1986). The methane in the heavy-oil and "tar" belt is interpreted by Deroo *et al.* (1977, p. 100) as "biogenic" gas. If this were so, it would be logical to expect the "biogenic" generation to have commenced in Albian time, during deposition of Lower Mannville sediments. Biogenic gas would then have filled the large Lower Cretaceous paleotraps, thus excluding the oil which is supposed to have been generated much later.

The intimate association of methane with the heavy-oils in these stratigraphically-complex sand reservoirs suggests their contemporaneous generation, with the methane facilitating the migration of heavy-oil molecules. The stratification of heavy-oils in *Lloydminster* reservoirs (Wennekers *et al.*, 1979) suggests gradual gravity segregation during early maturation of a mixture of "biogenic" oil and gas.

SOURCES OF IMMATURE OIL

It has become the custom for geochemists to designate source rocks for petroliferous basins on the basis of TOC (Total Organic Carbon) and vitrinite (maturity) measurements. This frequently leads to a rather sparse assortment of sources, and the necessity to call upon long-range migration to fill traps that reside outside "oil kitchens".

The argument that oil in lenticular traps demands a proximal source (Wilson, 1975) has convinced few geochemists.

Emphasis has traditionally been placed on kerogen as the source for reservoired oil, but kerogen itself is a very complex substance that is not well-understood, and most organic-geochemical research has been carried out on lipid extracts that represent only 5% of the total organic matter in sediments (MacKenzie *et al.*, 1982).

The generation and retention of enormous volumes of hydrocarbons during burial of organically-rich sediments is established without doubt by the presence of oil shales throughout the geological column. What interests the petroleum geologist, however, is the much smaller volume of hydrocarbons that has been freed from the organic parent material to accumulate in porous traps, and when that release occurred. This raises, *inter alia,* the important question referred to by MacKenzie *et al. (op. cit.,* p. 501) of distinguishing between the relative importance of in-reservoir maturation of oil, and the late introduction into reservoirs of oil matured-in (and expelled-from) source rocks.

If the evidence for very early generation and emplacement of biogenically-generated oil is used as a basis for interpretation, then it is suggested that the interface between a reservoir rock and its immediate cover of anoxic sediments could be an important site for thriving colonies of anaerobic bacteria. These bacteria would subsist and multiply on organically-rich fluids expressed from the overlying sediments during the early stages of sedimentary compaction.

Immature hydrocarbons transformed by these micro-organisms might be entrained by methane molecules, similarly generated, to accumulate in penecontemporaneous traps, such as the paleomorphological swells in the *Athabasca* region. In this way, the pores of unconsolidated sands would be protected from cementation, and fragments of driftwood would be impregnated with inhibiting hydrocarbons.

The organic make-up of the oil would thus be influenced, not only by the mix of microorganisms, but also by the composition of liquid feedstock that might be expressed from the cover of paludal, marine or evaporitic sediments.

Such a mechanism would fit harmoniously with the analysis of oil generation and accumulation in Chinese basins (Zhang Yi Gang, 1981), where source rocks have surprisingly low TOC contents (Kelts, 1985, p. 268); to the early generation and migration of oil in Neogene sediments of Japan (Taguchi, 1983, p. 485); and to the habitat of oilfields in the Middle East (Wilson, 1982).

CONCLUSIONS

Well-documented geological evidence for the preferential charging of early-formed traps, contrasting diagenetic evolution and rock compaction inside and outside oil reservoirs, and the occurrence of deformed oil-water contacts, all imply the early introduction of oil into paleotraps.

Geological and geochemical evidence from the *Athabasca* heavy-oil belt combine to fortify the conclusion that these enormous volumes of heavy-oil are the result of early, immature oil generation from proximal sources, and are not the product of biodegraded mature oil.

Biodegradation and water washing require that an oil accumulation be brought into contact with bacteria-laden meteoric waters. However, "tar mats" that form at the oil-water interface appear, from many examples, to be excellent self-sealing mechanisms which would halt the pervasive bacterial incursions that must be assumed for the general degradation of oil pools such as those in the *Athabasca* region.

The fact that hydrocarbons can be distilled from organic-rich rock has been known since the inception of the oil-shale industry, which itself is witness to the enormous oil-retentive power of lithified petroliferous rocks. The problem that separates catagenic oil generation from economic oil pools is the migration link. Neither primary migration from deeply-buried and lithified source rocks, nor long-distance secondary migration in deeply-buried carrier beds, have been verified, although many different mechanisms have been proposed (Barker, 1984; Brooks and Glennie, 1987).

Vitrinite reflectance values can help in predictions of the level of maturation that an oil may have reached, although the coexistence of oils of differing API values, such as those in the Tertiary reservoirs of the Oficina area (Renz *et al.*, 1958), or the Paleozoic Cherokee reservoirs of Kansas (Ebanks and James, 1974), highlight the influence of source variation and reservoir catalysts on ultimate oil type (Alexander *et al.*, 1981).

The preferential charging of early traps explains the greatly-improved porosities and permeabilities that so frequently are seen in oil reservoirs when compared to the properties of surrounding water-wet rocks. Not only do synchronous "highs" provide favourable sites for the winnowing of clastics or leaching of carbonates, but the early-emplaced hydrocarbons preserve those porosities and permeabilities against progressive compaction, cementation and diagenetic plugging of pores, factors which persist below the hydrocarbons and seal the accumulation in place.

It is concluded here that micro-organisms, principally bacteria, thriving and multiplying on organic-rich fluids expelled at the interface between a porous reservoir and overlying euxinic sediment soon after deposition, provide the energy for the transformation of organic matter into proto-oil, which itself may be largely formed from the body-sheaths of these bacteria. This, of course, raises questions regarding the exclusivity of organic-rich sediments as sources of oil.

Migration of heavy hydrocarbon molecules into proximal traps would be facilitated by the concomitant generation of "biogenic" methane, as has been observed in the Huanghua Basin, China (Liang Fuhua, 1987, p. 329).

The recognition that immature oil may have accumulated in large volumes, and not only as an exception to the presumed dominance of late generation and migration, harmonizes with the geological observation of preferential charging of early traps, and also provides a credible solution to problems of primary migration, this being from proximal sources during early compaction.

As was suggested by Barton (1934) and confirmed by Conti (1982), it is logical to conclude that pools of mature oil result from in-reservoir maturation of an original immature charge, this being the first step in natural "cracking", which, with continued burial, will be followed by transformation of the oil into condensate, and ultimately to methane and pyrobitumen.

Comparison of trap-fill statistics between shallow and deep accumulations does not support the contention that the more deeply-buried traps benefit from successive pulses of catagenically-generated hydrocarbons. In fact, many of the world's largest oilfields reside at shallow depths.

Deeply-buried oil- and gasfields are, almost invariably, tightly-sealed, and produce by depletion drive. Also, shallower fields are often sealed at the oil-water contact by "tar" or diagenetic permeability barriers, such that later-generated hydrocarbons would be barred from entry.

The general conclusion from these obsevations is that catagenically-generated hydrocarbons remain bound in the host rock, because the absence of effective permeability prevents their expulsion.

Large expenditures continue to be made on exploration strategies that are predicated upon the reality of catagenic generation and expulsion of oil. Such assumptions differ fundamentally from those linked to early oil generation, which require a very different exploration approach (Wilson, 1975).

The objective of this paper is not to turn back the interpretational clock, but to stress that in a many-faceted problem such as oil generation and migration, *bona fide* observations from all branches of geoscience must be taken into account when seeking a solution. When such an integrated approach is applied, it appears that oil habitat in sedimentary basins around the world is better explained by Orton's (1888) concept of early generation and accumulation of oil by organic decomposition, than by the currently-popular "distillation" hypothesis.

ACKNOWLEDGMENTS

The Author is most grateful to Messers. Gerald F. Friedman, Rufus J. LeBlanc, Richard R. Bloomer and Daniel A. Busch, who have read the manuscript and provided helpful and constructive criticisms.

REFERENCES

Aramco Staff, 1959, *Ghawar* oilfield, Saudi Arabia. *AAPG Bull.*, 43, 434-454.

Adasani, M., 1967, The North Kuwait Oilfields. 6th Arab Petrol. Congr.

Adkins, W. S., 1956. Age of Folding in East Texas Salt Domes. 20th Int. Geol. Congr.. (Mexico), *Abstracts*, p. 24.

Al Rawi, M. M., 1981. Geological interpretation of oil entrapment in the Zubair formation, *Raudhatain* field. Soc. Petrol. Eng., SPE 9591.

Alexander, R. *R.*, Kagi, I., and Woodhouse, G. W., 1981. Geochemical Correlation of Windalia oil and extracts of Winning Group (Cretaceous) potential source rocks, Barrow sub-basin, Western Australia. *AAPG Bull.*, 65, 235-250.

Ayres, M. G., *et al.*, 1982. Hydrocarbon habitat in main producing areas, Saudi Arabia. *AAPG Bull.*, 66, 1-10.

Bailey, N. J. L., Jobson, A. M., and Rogers, M. A., 1973. Bacterial degradation of crude oil: Comparison of field and experimental data. *Chem. Geol.*, 11, 203-221.

Ball, M. W., 1935. *Athabasca* Oil Sands: Apparent example of local origin of oil. *AAPG Bull.*, 19, 153-171.

----------, 1941. Development of the *Athabasca* Oil Sands. *Transactions,* Can. Inst. Min. Metall., 44, 58-91.

Barker, C., 1984. Advances in organic geochemistry. Bjoroy, M., (Ed.), John Wiley & Sons. A Review: *AAPG Bull*, 68, 395-396.

Barnes, D. J. and Dusseault, M. B, 1982. The influence of Diagenetic Microfabric on Oil Sands Behavior. *Canad. Journ. Earth Sci.*, 19, 804-818.

Barton, D. C., 1934. Natural history of the Gulf Coast crude oil. In: Problems of Petroleum Geology. *AAPG Mem.*, 109-155.

Bashbush, J. L., Savage, W.K., Nagai, R. B., Tadao Ogimoto, Jun Wakamiya and Hiroo Takizawa, 1983. Reservoir optimization study - *El Bunduq* Field, Abu Dhabi, Qatar. Soc. Pet. Eng., 3rd Mid. East Oil Show. *Paper SPE 11481*, 323-329.

Becher, J. W. and Moore, C. H., 1976. The *Walker Creek* Field: A Smackover diagenetic trap. Gulf Coast Assoc. Geol., *Soc. Transact.*, 26, 34-56.

Bennett, L., 1974. The Universe and Dr. Einstein. William Morrow & Co. Inc. Bantam Book Edition, 128 p.

Boigk, H, 1981. Erdol und Erdolgas in der Bundesrepublik Deutschland. Ferdinand Enke Varlag. Stuttgart.

Boles, J. R. and Ramseyer, K., 1987, Diagenetic Carbonate in Miocene Sandstone reservoir, San Joaquin Basin. California. *AAPG Bull.*, 71, 1475-1487.

Bortz, L. C., 1987. Heavy-oil deposit. Great Salt Lake, Utah. *In:* AAPG *Studies in Geology*, 25, 555-563.

Brooks, J. M. and Glennie, K. 1987: An overview on the third Conference on Petroleum Geology of NW Europe - Past, present and future exploration in NW Europe. Institute of Petroleum *Review,* February 1987. 42-44.

Brooks, P. W. and Macqueen, R. W., 1987. Implications of biomarker geochemistry to the origin of oil sands and heavy oils of the Western Canada Basin. *Canad. Soc. Petrol Geol.*, 14 (8). 1-3.

Burley, S. D., 1986. The development and destruction of porosity within Upper Jurassic reservoir sandstones of the *Piper* and *Tartan* fields, Outer Moray Firth, North Sea. *Clay Minerals*, 21 (4). 649-694.

Carrigy, M. A., 1971. Deltaic Sedimentation in Athabasca Tar Sands. *AAPG Bull.*, 55, 1155-1169.

Chapman, R. E., 1983. Petroleum Geology. Elsevier Developments in Petroleum Science, 415 pp.

Church, H. V, and Krammes, K. F., 1957. Correlation section across central San Joaquin Valley from San Andres fault to Sierra Nevada foothills. AAPG Pacific Sec. Correlation, Section 9.

Connan, J., 1972. Laboratory Simulation and Natural Diagenesis. 1. Thermal Evolution of Asphalts from the Aquitaine Basin (SW France). *Bull. Centre Rech. Pau.*. Soc. Nat. Petrol. d'Aquitaine *Bull.*, 6, (1), 195-214.

-----------, and Van der Weide, B. M., 1974. Diagenetic Alteration of Natural Asphalts. In: Oil Sands - Fuel of the Future. *Can. Soc. Petrol. Geol. Mem.*, 134-147.

----------, and Coustau, H., 1987. Influence of the Geological and Geochemical Characteristics of Heavy Oils on their Recovery. In: *AAPG Studies in Geology:* 25, 261-279.

Corbett, C.S., 1955. *In situ* origin of McMurray oil of north eastern Alberta and its relevance to general problem of origin oil. *AAPG Bull.*, 39, 1601-1649.

Conti, R., 1982. Stratigraphic distribution of hydrocarbons with differing API gravities in the East Texas basin. *Transactions,* Gulf Coast Assoc. Geol. Socs., 32, 199.

Cornelius, C. D., 1987. Classification of Natural Bitumen: A Physical and Chemical Approach. In: *AAPG Studies in Geology,* 25, 165-174.

D'Heur, 1984. Porosity and hydrocarbon distribution in the North Sea Chalk reservoirs. *Marine Petrol. Geol.,* 1, 211-238.

Dahlberg. E. C., 1982. Applied Hydrodynamics in Petroleum Exploration. Springer-Verlag, New York.

Davis. C. A., 1952. The North Coles Levee field Pressure Maintenance project. *Journa. Petrol. Technol.,* Aug. 1952, Sec. 1, 11-21.

Denison, A. R., Oldham, A. E., and Kisling, J. W., 1933. Structure and Stratigraphy, Kelsey Anticline, Upshur County. Texas. *AAPG Bull,* 17, 656-679.

Deroo, G., Tissot, B., McCrossan, R. G., and Der, F., 1974. Reply to Discussion by D. G. Montgomery, *In:* Oil Sands - Fuel of the Future. *Canad. Soc. Petrol. Geol. Mem.,* 3, 186-189.

Deroo, G., Tissot, B., McCossan, R. G., and Der, F., 1974. Geochemistry of the Heavy Oils of Alberta. In: Oil Sands - Fuel of the Future. *Canad. Soc. Petrol. Geol. Mem.,* 3, 148-167.

Deroo, G., Powell, T. G., Tissot, B., and McCrossan, R. G.. 1977. The Origin and Migration of Petroleum in the Western Canadian Sedimentary Basin, Alberta. *Geol. Surv. Canada Bull,* 262.

Dickey, P. A., George, G. O., and Barker, C., 1987. Relationships Among Oils and Water Compositions in Niger Delta. *AAPG Bull.*, 71, 1319-1328.

Dunnington, H. V., 1967. Aspects of diagenesis and shape change in stylolitic reservoirs. 7th World Petrol. Congr., Mexico. *Paper* PD 3, (4) 57-81.

Ebanks, W. J. and James, G. W., 1974. Heavy-crude bearing sandstones of the Cherokee group (Desmoinian) in SE Kansas. *Canad. Soc. Petrol. Geol. Mem.*, 3 19-34.

El-Aouar and Rasool, A. A., 1970. Development of the

Minagish oolite reservoir, *Minagish* Field, Kuwait. 7th Arab Petrol. Congr., *Paper 87* (B-l).

Ells, S. C., 1926. Bituminous Sands of Northern Alberta, Occurrence and Economic Possibilities. Report on Investigations to the end of 1924. Canad. Dept. Mines, *Rep. 632.*

Feazel, C., Keany, T. J., and Peterson, R.M., 1985. Cretaceous and Tertiary Chalk of the *Ekofisk* field area, Central North Sea. In: Carbonate Petroleum Reservoirs, P. O. Roehle and P. W. Choquette, (Eds.). Springer Verlag. 497-507.

Friedman, G. M., and Sanders, J. E., 1978. Principles of sedimentology. New York, John Wiley and Sons, 792 p.

Fuchtbauer, H., and Goldschmidt, H., 1964. Aragonitische Lumachellen im bituminosen Wealden des Emslandes. *Beitroge zur Mineralogie und Petrographie,* 10, 184-197.

George, A. E., Banerjee, R. C., Smiley. G. T., and Sawatzky, H., 1977. Simulated Geothermal Maturation of *Athabasca* Bitumen. *Bull. Canad. Petrol. Geol.,* 25, (5) 1085-1096.

Goodarzi, F., 1985. Preservation and characteristics of plant remains in Iranian natural bitumens. *Int. Journ. Coal Geol.,* 4, 321-334.

Grabowski, G. J., 1981. Source rock potential of the Austin chalk, Upper Cretaceous, SE Texas. *Transactions,* Gulf Coast Assoc. Geol. Socs., 31, 105-112.

Harding, T. P., 1976. Tectonic significance and hydrocarbon trapping consequences of sequential folding synchronous with San Andres faulting. San Joaquin Valley, California. *AAPG Bull.,* 60, 356-378.

Hardoin, J. L., 1962. *North Coles Levee* oil field. California Division of Oil and Gas. *Summary of Operations,* California Oil Fields, 48, 39-45.

Hassan, T. H., and Azer, S., 1985. The occurrence and origin of oil in offshore Abu Dhabi. Soc. Petrol. Eng.. 4th Middle East Oil Show. *SPE 139696,* 143-149.

Heald,. K. C., 1940. Essentials for oil pools. Chapter IV. In: Elements of the Petroleum Industry. E. DeGolyer (Ed.). America Institute of Mining and Metallurgical Engineers, New York, 26-61.

Hedberg, H. D., 1964. Geologic aspects of origin of Petroleum. *AAPG Bull.,* 48, 1755-1803.

Hills, L. V., (Ed.), 1974. Oil Sands - Fuel of the Future. *Canad. Soc. Petrol. Ceol. Mem.,* 3, 263 p.

Hunt, J. M., 1979. Petroleum Geochemistry and Geology. W. H. Freeman and Co., San Francisco.

-------------, 1987. Primary and Secondary Migration of Oil. In: *AAPG Studies in Geology,* 25, 345-349.

Isaacs, C. M., 1987. Sources and Deposition of Organic Matter in the Monterey Formation. South Central Coastal Basins of California. In *AAPG Studies Geology.* 25, 193-206.

Jackson, P. C., 1984. Paleogeography of the Lower Cretaceous Mannville Group of Western Canada. In: *AAPG Mem.,* 38, 49-77.

Jardine, D., 1974. Cretaceous oil sands of Western Canada. *In:* Oil Sands-Fuel of the Future. *Canad. Soc. Petrol. Geol. Mem.,* 3, 50-67.

Johnson, J. A. D., and Budd, S. R., 1975. The Geology of the Zone B and Zone C Lower Cretaceous limestone reservoirs of *Asab* field, Abu Dhabi. 9th Arab Petrol. Congr., *Paper* 109, (B-3).

Johnston, D. D, and Johnson, R. J., 1987. Depositional and diagenetic controls on reservoir quality in First Wilcox sandstone. *Livingstone* Field, Louisiana. *AAPG Bull.,* 71, 1152-1161.

Jones, R. W., 1980. Some mass balance and geological constraints on migration mechanisms. In: Problems of Petroleum Migration. *AAPG Studies in Geology,.* 6, (10): W. H. Roberts and R. J. Cordell (Eds.), pp. 47-68.

Kaveh, H.h Azar-Pey, A., and Sayah, E. R., 1971. Iran Pan American geological and geophysical methods in the Persian Gulf area. 8th World Petrol. Congr. 2, 131-148.

Kelts, K., 1985. Petroleum source rocks in lakes. *Episodes,* 8, (4), p. 267-268.

Khalaf, F. I., Gharib, L. M., and Mukhopadhyay, A., 1985. The Diagenesis of Reservoir Sands of the Zubair formation (Early Cretaceous), Northern Kuwait, Arabian Gulf. *Journ. Petrol Geol.,* 8 (2), 149-161.

Kramers, J. W., 1974. Geology of the *Athabasca* "A" Oil Sand Deposit (Grand Rapids Formation). *In:* Oil Sands - Fuel of the Future. *Canad Soc. Petrol. Geol. Mem.,* 3, 68-83.

Lee, W. and Payne, T. G., 1944. *McLouth* gas and oil field, Jefferson and Leavenworth counties, Kansas. State Geological Survey of Kansas, *Bull.,* 53, 8-194.

Levorson, A. L., 1954. Geology of Petroleum. W. H. Freeman & Co. 703 pp.

Leythaeuser, D., 1987. Recognition and Quantification of Petroleum Expulsion from Shale Source Rocks. *In: AAPG Studies in Geology,* 25, 341-344.

Liang, Fuhua, 1987. Zonation of oil and gas in the Huanghua basin, China. *Journ. Petrol. Geol.,* 10, 327-334.

Liddle, R. A., 1936. The Van Oilfield. Van Zandt County, Texas. Texas Bur. Econ. Geol. *Bull,* 3601, 1-79.

Litsey, L. R., McBride, W. L., Al-Hinai, K. M., and Dismutes, N. B., 1983. Shuaiba reservoir geology study. *Yibal* field, Oman. Soc. Pet. Eng.. 3rd Mid. East Oil. Tech. Conf., *Paper SPE* 11454.

Lorshbough, A. L., 1967. Western portion of *Elk Hills* oil field. California Division of Oil and Gas, *Summary of Operations,* California Oil Fields 53, (1), 33-37.

Mackenzie, A. S., Brassell, S. C., Eglinton, G., and Maxwell, J. R., 1982. Geochemical fossils: The Geological Fate of Steroids. *Science.* 217, 491-504.

Maher, J. C., Carter, R. D., and Lantz, R. V., 1975. Petroleum Geology of Naval Petroleum Reserve No. I Elk Hills, Kern Co., California. *USGS Prof. Paper,* 912, 109 pp.

Mallinson, J. E., and Sharp, J. W. G., 1975. Reservoir engineering aspects of the development of the *Asab* field. 9th Arab. Pet. Congr., 137, (B-l).

Masters, J. A., 1979. Deep Basin Gas Trap, Western Canada. *AAPG Bull.,* 63, 152-181.

------------, 1984. Lower Cretaceous Oil and Gas in Western Canada. *In: AAPG Mem.,* 38, 1-34.

Matheny, S. L., 1979. WEDCO expands Cold Lake Heavy-Oil Production. *Oil and Gas Journ.,* Oct. 29th. 104-118.

McCoy, A. W., and Ross Keyte, W., 1934. Present interpretations of the structural theory for oil and gas accumulation. *In:* Problems of Petroleum Geology. Sydney Powers Memorial Volume, pp. 253-308.

Mekkawi, A. S., 1979. Reservoir engineering: its role in hydrocarbon resources development. OAPEC *working paper,* 11-29.

Montgomery, D. S., 1974. Geochemistry of Heavy Oils of Alberta - Discussion. In: Oil Sands -Fuel of the Future. *Can. Soc. Petrol. Geol. Mem.*, 3, 184-185.

-----------, Clugston, D. M., George. A. E., Smiley. G. T., and Sawatzky., H., 1974. Investigation of Oils in the Western Canada Tar Belt. In: Oil Sands - Fuel of the Future. *Canad. Soc. Petrol. Geol. Mem.*, 3, 168-183.

Mossop, G. D., 1980. Geology of the *Athabasca* Oil Sands. *Science,* 207, 145-152.

Orisson, G., Albrecht, P., and Rohmer, M., 1984. The Microbial Origin of fossil fuels. *Sci. Am.*, Aug. 1984, 44-51.

Orr, R. D., Johnston, J. R., and Manco. E. M.. 1978. Lower Cretaceous Geology and heavy-oil potential of the *Lloydminster* Area. *Journ. Canad. Petrol. Technol.,* Jan.-Mar., 1978. 73-89.

Orton, E., 1888. The origin and accumulation of Petroleum and Natural Gas. In *Report* of the Geological Survey of Ohio, 6, Chapter 2, pp. 60-100.

Paxson, J. R., 1984. Problems in the characterization of heavy and less heavy crude oils. In: *AAPG Studies in Geology,* 25, 159-164.

Payzant, J. D., Montgomery, D. S., and Strausz, O. P., 1986. Sulphides in Petroleum. *Org. Geochem.,* 9, (6), 357-369.

Petersen, N. F, and Hickey, P. J., 1987. California Plio-Miocene Oils: Evidence of early generation. *In: AAPG Studies in Geology,* 25, 351- 360.

Price, W. A., 1972. Origins of Anticlinal Theory and State of Oil Finding in 1910-1910: Discussion. *AAPG Bull,* 56, 2464.

Renz, H. H., Alberding, H., Dallmus, K. F., Patterson, J. M., Robie, R. H., Weisbord. N. E., and Masvall, J., 1958. The Eastern Venezuelan Basin. In AAPG Symposium - Habitat of Oil, pp. 551-600.

Roach, J. W., 1987. Biogenically formed petroleum should be considered. *World Oil,* June 1987, 84-91.

Rodifer, R. E., 1987. Size Distributions of the World's Largest Known Oil and Tar Accumulations. *In: AAPG Studies in Geology,* 25, 3-24.

Roberts III, W. H., 1987. Common Conditions for Heavy Oils. *In: MPG Studies in Geology,* 25, 453-472.

Roberts, W. H, and Cordell, R. J., 1980. Problems of Petroleum Migration. *MPG Studies in Geology,* 10, Introduction.

Rottenfusser, B., 1982. Sedimentology and diagenesis of the Gerthing Formation, Peace River Oil Sands, NW Alberta. *Canad. Soc Petrol. Geol., 9,* (11), 2.

Samman, N., Ignasiak, T., Chen, C.-J., Strausz, O. P., and Montgomery, D. S., 1981. Squalene in Petroleum Asphaltenes. *Science,* 213, 18 Sept., 1981, 1381-1383.

Schneeflock, R., 1978. Permeability Traps in Gatchell (Eocene) sand of California. *MPG Bull.,* 62, 848-853.

Scholle, P. A., 1977. Chalk diagenesis and its relation to petroleum exploration: Oil from Chalks, a Modern Miracle? *MPG Bull.,* 61, 982-1009.

Scott. J. D., 1987. Coring and Sampling in Heavy-Oil Exploration: Difficulties and Proposed Cures. *In: MPG Studies in Geology,* 25, 437-442.

Simonson, R. R., 1958. Oil in the San Joaquin Valley, California. *In:* Weeks, L. G. (Ed.), Habitat of Oil. AAPG Symposium, 99-112.

Smith, G. E., 1986. Fluid Flow and Sand Production in Heavy Oil Reservoirs under Solution Gas Drive. 56th Annual Society of Petroleum Engineers Regional Meeting. *Proc.,* 2, 29-41.

Sproule, J. C., 1938. Origin of McMurray Oil Sands, Alberta. *MPG Bull.,* 22, 1133-1152.

Stock, C., 1972. Rancho La Brea, a record of Pleistocene Life in California. Los Angeles County Museum of National History, *Science Series* 20, Paleontology 11, (7th edition), 81 pp.

Surdam, R. C. and Crossey, L. J., 1985. Organic-inorganic reactions during progressive burial: key to porosity and permeability enhancement and preservation. *PhiL Trans. Roy. Soc. Lond.,* 315, 135-156.

Taguchi, K., 1983. Petroleum geochemistry in the Neogene sedimentary basin of Japan, with special reference to primary migration. *Journ. Geol. Soc. Lond.,* 140, 475-487.

Tannenbaum, E. and Aizenshtat, Z., 1984. Formation of immature asphalt from organic-rich carbonate rocks - II. Correlation of maturation indicators. *Organic Geochem.,* 6, 503-511.

Thomas, M. B. and Miller, B., 1980. Diagenesis and rock fluid interactions in the Cadotte member from a well in NE British Columbia. *Bull., Canad. Petrol. Geol.,* 28, (2), 173-199.

Tissot, B. P. and Welte, D. H., 1978. Petroleum Formation and Occurrence. Springer-Verlag, 538 pp.

Tornabene, T. G., 1981. Formation of hydrocarbons by bacteria and algae. *In:* Trends in the biology of fermentations for fuels and chemicals (A. Hollaender, Ed.), pp. 421-438, Plenum, New York.

Van Tuyl, F. M, and Parker, B. H., 1941. The time of origin and accumulation of petroleum. *Colorado School of Mines Quarterly,* 36, (2).

Van Tuyl, F. M, and Parker, B. H., 1937. Petroleum Genesis: Geologic distillation vs. contemporaniety hypothesis. *Pan American Geologist,* 67, 109-116.

Vigrass, L. W., 1968. Geology of Canadian Heavy Oil Sands. *MPG Bull.,* 52, 1984-1999.

Vinogradov, L. D., 1979. Formation of enclosed oil and gas pools and applicable prospecting methods. *Science and Technology Digest,* Moscow, 91 pp. *(in Russian).*

Warren, J. K., 1986. Shallow-water evaporitic environments and their source rock potential. *Journ. Sed. Pet.,* 56, (3), 442-454.

Weddle, H. W., 1951. *Pleasant Valley* oil field, Fresno County, California. *MPG Bull.,* 35, 619-623.

Weeks, L. G., 1961. Origin, migration, accumulation and occurrence of petroleum. *In:* Petroleum exploration handbook, Chapter 5. New York, McGraw-Hill.

Weeks, L. G., 1948. Basin development. sedimentation and oil occurrence. Standard Oil Company. *Unpublished Report* (in Library of Congress). Chapter 39. The *Athabasca* bitumen sands, pp. 190-203.

Welte, D. H., Schaefer, R. G., Stoessinger. W., and Radke, M., 1984. Gas generation and migration in the Deep Basin of Western Canada. In: *AAPG Memoir,* 38, 35-48.

Welte, D. H., De Groot, K., and Nasr, S. N., 1980. Panel Discussion - Origin, Migration and Accumulation of Hydrocarbons. 10th World Petrol. Congr., 2, 49-54.

Wendlandt, E. A., Shelby, T. H., and Bell, J.S., 1946. *Haukins* Field, Wood County, Texas. *AAPG Bull.,* 30, 1830-1856.

Wennekers, J. H. N., Ryckborst, H., Abougoush, M. S., McCreary, R. K. V., and Letkeman, J. P., 1979. Heavy Oil, Tar Sands Play Key role in Alberta, Saskatchewan Production. *Oil and Gas Journ.*, Nov. 12, 1979, pp. 290-304 and Nov. 19, pp. 193-198.

Wilson, H. H., 1975. Time of hydrocarbon expulsion, paradox for geologists and geochemists. *AAPG Bull.*, 59, 69-84.

------------, 1977. Frozen in hydrocarbon accumulations or diagenetic traps - Exploration Targets. *AAPG Bull.*, 61, 483-491.

------------, 1982. Hydrocarbon Habitat in Main Producing areas, Saudi Arabia: Discussion. *AAPG Bull.*, 62, (12), 2688-2691.

Zhang Yi Gang, 1981. Cool shallow origin of petroleum - microbial genesis and subsequent degradation. *Journ. Petrol. Geol.*, 3, 427-444.

Zobell, C. E., 1945. The roll of bacteria in the formation and transformation of petroleum hydrocarbons. *Science*. 102, (October 12), 364-369.

ABOUT THE AUTHOR

H. Hugh Wilson is Chief Geologist for Banner Energy and consultant on international exploration. He received a B.S. in natural science from Dublin University in 1950 and an M.S. degree in geology from the same university in 1952. Upon graduation, Mr. Wilson joined Royal Dutch Shell and spent the next 17 years in various areas of the world: as field geologist in Colombia. chief geologist and head of exploration in Turkey, exploration manager in Guatemala. exploration manager of the Arabian Gulf and Oman area. general manager of exploration and production in Australia, and in management programs in London. In 1969, he transferred to Shell U.S. where he worked primarily the Gulf Coast area. In 1973, Hugh resigned from Shell to join a consulting firm in New Orleans, and later became a consultant to Louisiana Land and Exploration Company. After six years of looking after worldwide projects for LL&E. he formed his own consulting firm, Vanguard Exploration. In 1983 he joined Superior Oil as a staff explorationist and in August of 1984 went to work for Sohio in international exploration. He retired from Sohio in 1988.

Mr. Wilson has published papers on a wide range of technical topics and geographical areas. These papers appeared in such publications as AAPG bulletins, Geology Magazine, Journal of the Institute of Petroleum, GCAGS Transactions, and the Journal of Petroleum Geology. The areas covered by his papers have included the U. K., Central America, the Oman Mountains, the Gulf of Mexico, Saudi Arabia, and Mexico. He has dealt with such diverse subjects in his papers as salt tectonics, diagenetic traps for hydrocarbons, orogenic pulses, and timing of hydrocarbon expulsion. In addition, he has been a lecturer for the Advanced Petroleum Geology courses at Tulsa University and for in-house exploration seminars within oil companies. He was key speaker at the GSA Penrose Conference on Geodynamics of Continental Interiors, and has been guest speaker at geological societies in California. Louisiana and Texas. He has served as Associate Editor of AAPG and was a team member of the International Geodynamics Project working on global synthesis of evidence leading to the reconstruction of distribution of continents and oceans through time.

Mr. Wilson is a fellow of the Geological Society of London and the Institute of Petroleum in London. He is a member of the Geological Society of America, the American Association of Petroleum Geologists, and the Houston Geological Society.

ON THE MOVE

Chris Dibler is pleased to announce that he is now an agent for AIA Insurance. Dibler Seismic Service, Inc. has changed their Corpus Christi and Houston telephone numbers. The new phone number is 713-341-1705. The address remains: P.O. Box 1006, Richmond, Texas 77469.

Bob C. Jones, Chief Geophysicist with Marathon Oil Company, has accepted early retirement. He will continue to reside in the Houston area and will be available for consulting.

M. Charles Manske has joined the Houston staff of OMNI Laboratories, Inc. as Senior Geologist specializing in international projects. Previously, he was Geologist and Staff Geologist at David K. Davies and Associates in Kingwood, Texas.

Dennis W. Cratsley has recently joined the Minerals Management Service in New Orleans as a Resource Evaluation Geologist. Formerly with IBM E&P Data Management Systems, Texas Eastern Corp., Ocean Production Co., and Amerada Hess Corp.

Craig Brooks has joined GeoSearch, Inc. in Houston as Louisiana District Geologist. He joins Jeff Mills at 4669 Southwest Freeway, Suite 800, Houston, Texas 77027. Phone (713) 888-7878, FAX (713) 888-7882.

EXPLORATION ACTIVITY REVIEW

By Bill Eisenhardt
Consultant, Geol. Representative—Geomap Co.

National Rig Count: April 25—623; Year Ago—824
Gulf of Mexico Rig Count: 70

GULF COAST

Texas

Shell Western E&P is drilling ahead at the #1 Jerico Ltd., an 18,000′ **Wilcox** wildcat ½ mile southwest of Frio production at El Tule Field in north-central **Hidalgo** County. Closest current Vicksburg production is 1 ¼ miles west at Schmidt Field. At the middle Frio horizon the new test spots on the south end of a broad east plunging nose, with more pronounced anticlinal development (and faulting) anticipated at the deeper Vicksburg level.

In northeastern **Zapata** County, Placid Oil has opened Rufino Lopez Field at its #1 Josefa, a new **Wilcox** discovery about 1/3 mile west of the old (1921) multi-pay Mirando Valley Field. Flow rate was 3,727 MCFGPD (4,900 MCFGPD-CAOF) through perfs 13,144-234′(OA) in the reported "13th Hinnant Sand" of the Wilcox. At the Carrizo Wilcox horizon the new producer spots on local northeast dip between a pair of down-to-the-east faults.

Tri-C Resources has staked an 8000′ **Wilcox** test in northwestern **Duval** County ½ mile northeast of Jackson production at Casa Blanca South Field. The #1 DCRC Section 63 is 1 ½ miles southwest of a 7215′ dry Wilcox test (Harkins #1 Lundell) and 3 miles northeast of nearest Wilcox production at DCR-79 Field. At the Carrizo Wilcox horizon the wildcat spots on southeast dip, immediately upthrown to a regional down-to-the-southeast fault.

Wildcatter Incorporated will drill an 1800′ **upper Georgetown** test in the northwestern corner of **Maverick** County, 4 ¾ miles northeast of Georgetown oil production at the one-well Esther Field. The #1 El Rancho Las Moras is one mile west of the Amoco #1 Burr Est., D&A at TD 6000′ in the Hosston. At the base Austin Chalk horizon the wildcat spots near the axis of a southeast plunging structural nose and updip to the #1 Burr Est.

Delcar has staked a 3450′ wildcat 2 miles north of Austin Chalk oil production at Poteet Field in northern **Atascosa** County. The #1 Mueller Unit will target both the **Austin Chalk** and the **Buda** about 1 ¾ miles northeast of Tenneco's dry Sligo test, the #1 Rogers. Structure at the Edwards "A" horizon is southeast regional dip.

In central **Live Oak** County, Nueces Oil has scheduled a 7600′ **Wilcox** test about 1 ½ miles northeast of Wilcox gas production at the one-well Clayton North Field. The #1 Herring Farm is about 3200′ northwest of the Herring #1 Zelma Herring, D&A in the Yegua at 2970′. Top Wilcox structure here appears to be southeast regional dip with broad local nosing, based on rather sparse control.

Great Western Onshore has opened Boss Gaston Field at its Paramount-McGuire, a new **Yegua** gas discovery 1 1/3 miles northeast of Yegua oil and gas production at State Farm Field in eastern **Fort Bend** County. Flow rate was 1,676 MCFGPD (11,618 MCFGPD-CAOF) through perfs 8274-82′. At the top Yegua horizon the new find appears to spot in a shallow saddle, immediately downthrown to a down-to-the-coast fault.

In southern **San Jacinto** County, Royal Oil & Gas has scheduled an 11,800′ **Wilcox** test on the southeastern edge of Mercy Field, productive from the Wilcox 8300′, 9100′ and 10,400′ sands. The #1-B Central Coal & Coke will be targeting Wilcox sands below the established field pay. Deepest Wilcox producer in the area was Superior's #1 Foster Lbr. Co., 3 miles southwest, which flowed 15 BOPD from 12,498-534′ and opened the now abandoned Mercy South Field. At the top Wilcox horizon the deeper pool wildcat spots on local southeast dip, downthrown to a regional down-to-the-south fault.

South Louisiana

Ballard Exploration will drill their #C-1 LaBokay, a 12,500′ **Cockfield** test, just over 2 miles east of Ballard's West Buxton Creek Field in northern **Calcasieu** Parish, discovered last year. Production here is from the 2-B sand between 11,651′ and 11,708′. At the Cockfield horizon the wildcat spots on southeast dip, downthrown to the same regional down-to-the-south fault responsible for the rollover structure at West Buxton Creek.

A 14,000′ ***Miogyp*** test will be drilled by Shell Western E&P between North Sweet Lake and Grosse Savanne fields in northern **Cameron** Parish. The #1 Hebert Estate Properties is 4000′ west of the dry Chevron #1 Davis which encountered numerous thin *Miogyp* sands between 13,100′ and 13,800′. At the *Marg idi* horizon the wildcat spots on the highly faulted north flank of the Sweet Lake-Grosse Savanne structure.

Arkla Exploration has staked an 11,820′ wildcat about 4 ½ miles southwest of Livingston Field in western **Livingston** Parish. The #1 Cavenham 12-12 will evaluate the **upper Wilcox,** the predominant pay at Livingston Field. The new test spots on a south plunging nose downthrown to a regional down-to-the-south fault at the Wilcox horizon, and is located about midway between two Wilcox dry holes, the Callon #2 CZ 15 to the north and the Union Texas #1 CZ to the southeast.

Farther northeast, in extreme eastern **St. Helena** Parish, Oxy USA will drill a 13,000′ **Lower Tuscaloosa** test about 3 ½ miles southeast of Tuscaloosa oil production at the one-well Greensburg NE Field. The #A-1 Lambert is 2 miles northeast of and updip from the dry 20,114′ Hunt #1 Phillips which logged water-bearing Lower Tuscaloosa sands between 12,700′ and 12,800′. Lower Tuscaloosa structure here is southwest regional dip with local nosing.

MESOZOIC TREND

East Texas

Barrow-Shaver Resources has staked an 8800′ **James** test one mile southwest of James production at Aventura Ranch Field in southern **Van Zandt** County. The #1 Phillips is about 2700′ south of Delta's #1 Martin, a 9010′ dry Travis Peak test, which cored the Rodessa at 8216-23′ with no shows. The James interval was reportedly not tested. Structure at the base Massive Anhydrite is regional southeast dip.

Farther east, in northwestern **Smith** County, Cook Exploration has scheduled a 10,000′ **Rodessa** wildcat, the #1 Fair, 1 ¼ miles northeast of Paluxy production at the Reed & Strawn #1 Cline, discovery well for Hide-A-Way Field (IPP 36 BOPD and 20 MCFGPD from 7552-71′). A small amount of oil and water was recovered from the Rodessa between 9648′-9734′. About 2700′ east of the new test, John Voight drilled a 5400′ Woodbine dry hole in 1961 (#1 Staples) with no tests reported. At the base Massive Anhydrite horizon the wildcat spots on the northeast flank of the faulted Lindale-Caney Creek structure.

North Louisiana

Palmer Petroleum will drill a 7500′ **Sligo** test in southwestern **Ouachita** Parish about 2 miles southeast of the abandoned Eros Field (Cotton Valley gas) and about 4 miles southwest of Cotton Valley, Rodessa and Hosston production at Cadeville Field. The #1 Riverwood International is 1 ½ miles northwest of and updip from the James #1 Crown Zellerbach, an 8600′ dry Hosston test which logged a well developed porous upper Sligo. Structure at the base Massive Anhydrite appears to be south regional dip, based on fairly sparse control.

Alabama

IP Petroleum is drilling ahead below 2600′ at its #1 Lancaster 18-14, a 13,500′ wildcat about 4 miles north of Frisco City Sand production at Frisco City Field in south-central **Monroe** County. The new test will also target the **Frisco City Sand,** a lower Haynesville sand, productive in a recent Torch Petroleum discovery about 2 miles south-west (540 BOPD and 716 MCFGPD). About 3000′ north, Kenmore Oil abandoned its #1 Barton in the Norphlet at TD 12,838′ after logging a well developed Frisco City Sand at 12,103′. No shows or tests were reported. At the top Smackover horizon the new venture spots on the north-west flank of a strong southwest plunging nose near the updip limit of the Smackover.

A new **Smackover** oil discovery has been completed by Great Western Onshore in southwestern **Conecuh** County about 2 miles northeast of Smackover oil production at East Barnett Field, discovered in 1988. The #1 G-W Edge-Gilmore flowed 438 BOPD (38° API) and 355 MCFGPD through perfs 13,650-670′. Smackover structure here appears to be southwest regional dip with local nosing. About 2 ½ miles southeast in adjoining **Escambia** County, Cobra Oil & Gas has completed its #1 ATIC-Callon as another **Smackover** oil discovery, flowing 277 BOPD (42° API) and 241 MCFGPD from three perforated intervals between 13,396′ and 13,416′. The new find is about 1 ½ miles northwest of Fina's recent #1 ATIC-1 discovery, and about 3300′ south of Coastal's #1 West dry hole which tested noncommercial in the Smackover. At the top Smackover horizon the new discovery spots near the crest of a small structural closure which possibly reflects a pre-Jurassic basement high.

INTERNATIONAL HIGHLIGHTS

Provided by PETROCONSULTANTS, Foreign Scouting Division, Geneva. Switzerland

LATIN AMERICA

Bolivia

Two gas/condensate discoveries in Cochabamba Province have enhanced the Maastrichtian and Devonian plays in the **Foothill Belt.** Maxus' 4291-m (14,079′) wildcat Surubi-1, the first drilled on the Mamore Block, penetrated a total of 115′ of net hydrocarbon pay in the **Maastrichtian Cajones** Formation. Tests of two zones gauged an aggregate of 9,000 MCFGPD and 800 BCPD (50° API). YPFB's 4771-m (15,654′) wildcat Carrasco X-1 tested flow rates of about 3,000 MCFGPD and 374 BCPD (60° API) from the **Cajones** and 6,000 MCFGPD and 648 BCPD (54 API) from the **Lower Devonian Robore** Formation.

Chile

ENAP's wildcat Lago Mercedes 1 in the Lago Mercedes concession has supported speculation of the presence of an important gas/condensate play in the **Permo-Triassic granite.** The wildcat, which had previously identified up to 3,000 MCFGPD and 750 BCPD in the Lower Cretaceous Springhill Formation, has also tested up to 12,000 MCFGPD and 2,000 BCPD (52° API) in the fractured **Permo-Triassic** granite basement between 3700 and 4050 m (12,140-13,288′), which was the primary objective.

ENAP has also confirmed the successful conclusion of the first horizontal drilling in Chile. Outpost Mata Negra 2 in the **Magallenes Basin** was completed as an oil well, presumably in the **Lower Cretaceous Springhill** Formation, after reaching a total measured depth of 3730 m (12,238′). It was the first appraisal of the 1989 Mata Negra 1 discovery.

Colombia

Ecopetrol's 2963-m (9722′) wildcat Yurilla 1 in the **Putumayo Basin** is now confirmed as an oil discovery. Tests of an unspecified formation, possibly the **Upper Cretaceous Villeta** sands, yielded 1,500 BOPD (31.8° API) and 249 MCFGPD. Location is 3.7 miles SSE of Ecopetrol's 1989 Mecaya-1 discovery, which tested 665 BOPD (27° API) in the Villeta.

EUROPE

Italy

Petrex and Agip have reportedly made a light oil discovery at Cerro Falcone 1 in the Monte Sirino permit (Lucania zone). Testing was continuing in late February. The wildcat is located 20 km (12.4 miles) south of Potenza, on trend with Petrex's Monte Alpi oil field. Originally projected to 3200 m (10,499′) to evaluate the Miocene and Upper Cretaceous limestones of the Inner Apulian Platform, Cerro Falcone 1 finally bottomed at 4405 m (14,453′).

United Kingdom (Offshore)

Agip tested 19,500 MCFGPD at its 43/21-2 wildcat north of the Ravenspurn gas field. Appraisal drilling is planned.

Ultramar's wildcat 44/16-1, between Gordon and Murdoch, tested 30,300 MCFGPD from the Carboniferous, with additional drilling planned.

AFRICA

Angola (Offshore)

Elf has made two oil discoveries in Block 3. Wildcat Caama Centro 1, located 7 ½ miles east of the Cobo Field, reportedly tested at rates of 5,000 BOPD. Similarly, tests at wildcat Oombo 1, about 3 miles south of the Cobo Field, gauged 4,770 BOPD from one undisclosed horizon, while a second zone flowed 3,610 BOPD.

Libya (Offshore)

In the **Pelagian Basin,** Sirte Oil abandoned its wildcat B-1-NC87 as a dry hole at TD 6035 m (19,800′), a record depth in Libya. The objective was the Lower Cretaceous, with an original planned TD of 4300 m (14,108′). Location is in Block NC 87, about 260 km (161 miles) northeast of Tripoli.

Nigeria

A discovery was made by the Nigerian company Summit Oil in the previously undrilled OPL 205 on the Benin flank of the **Niger Delta.** Wildcat Otien 1, technically operated by NPDC, reportedly encountered 19 pay zones and a combined 200 m (656′) gross hydrocarbons. Objectives in this northwestern part of the Delta are Late Eocene/Oligocene paralic and deltaic sandstones of the Agbada Formation.

NEAR EAST

Oman

PDO has announced two oil discoveries on the eastern flank of the **South Oman Salt Basin.** Wildcat Thurayah 1, located about 5 miles southeast of the Jalmud Field, was suspended after reaching TD 1682 m (5519′), while wildcat Nadheer 1, 15 ½ miles northeast of the Jalmud Field, was suspended at TD 1721 m (5647′). The pay in both wells is assumed to be in the **Carboniferous** to **Lower Permian Haushi** Group.

FAR EAST

Indonesia (Offshore)

In the SE Sumatra Offshore Block, Maxus has an oil discovery at its Ambar 2, located 17 km (10.6 miles) northwest of the Janti Field. The first of two drill stem tests flowed 607 BOPD from a fractured limestone at 1654-1663 m (5427-56′), while the second yielded 424 BOPD from a 23′ section between 1622-1637 m (5322-5371′) in the **Talang Akar** Formation **(Oligocene-Miocene).**

Total's wildcat Janu 1 in the Mahakam Delta Marine Block (Makassar Strait) was suspended as an oil well after testing 2,597 BOPD and 970 MCFGPD. The discovery, which was drilled to TD 3575 m (11,730′), is 1 ¼ miles southwest of the 1991 Semanlu 1 oil and gas discovery.

Off West Sumatra, Fina has commenced drilling operations in the Bengkulu Block. Wildcat Arwana 1, projected to a TD of 4100 m (13,452′), will target **Paleogene-Neogene** clastics and carbonates. No discovery has been made so far in the **Bengkulu Basin.**

Philippines (Offshore)

Latest reports indicate that Shell's exploration well Malampaya 1, located off Palawan in China Sea Block SC 38, has found gas and condensate. The wildcat is currently drilling below 3420 m (11,221′) towards the hydrocarbon/water contact. Drillsite is 5 ½ miles north of the Camago discovery, apparently on the northern tip of the same structure. Camago 1, drilled by Oxy in 1989, tested 24,600 MCFGPD and 809 BCPD from a Miocene reefal buildup.

Texas A&M University Department of Energy Sponsored Symposium on the Austin Chalk Producing Trend

June 3, 1992 - Texas A&M University Campus

The one-day symposium on June 3, 1992 is oriented to the independent and major producers in the Austin Chalk producing trend and is intended to be a technology transfer event. Ten papers covering geophysical, geological, drilling, production, reservoir characterization and new recovery methods are scheduled for presentation. The material is equally divided between researchers at Texas A&M University and operators who have displayed innovative methods in their operations in the Austin Chalk. The cost of the program is $65, which includes book of preprints and lunch, with Mr. Ray Holified as guest speaker. Please write the Petroleum Engineering Department, Texas A&M University, College Station, Texas 77840. Attn: Ms. Marilyn Garrett to register, or call, S.W. Poston, (409) 845-2289 for additional information.

"Support those who support our Society."

Geologist - Geophysicist - Engineer place your business card here. Send $113 with two cards and you're advertising all year.

GENEOS PETE COKINOS
PETROLEUM AND GEOLOGICAL ENGINEERING CONSULTANT
INDEPENDENT PRODUCER AND OPERATOR
947 HAZEL ST.
BEAUMONT, TX 77701
TELEPHONE (409) 832-0388
FAX (409) 838-3919
3919 E. WEAVER

Office: (713) 556-1784
(713) 870-0590
M.L. "Newt" Feldman
Consulting Geologist
Certified Petroleum Geologist
14119 Swiss Hill
Houston, TX 77077
14760 Memorial Dr., Ste. 300
Houston, TX 77079

PO Box 370931
Montara, CA 94037-0931
340 Seventh Street
(415) 728-3373
VICTOR H. ABADIE III
CONSULTING GEOLOGIST
CERTIFIED PETROLEUM GEOLOGIST, AAPG, NO. 3936
CALIFORNIA REGISTERED GEOLOGIST, LIC. NO. 4040

713 360 2711
P.O. Box 5181
Kingwood
Texas
77339
Marilyn Crane
Consulting Paleontologist
Foraminifera & Ostracodes Jurassic to Recent
Specialize in Gulf Coast and Offshore Atlantic

JOHN GREEN
JOHN W. GREEN CO.
Geophysical Consulting and Management
827 Americana Building
811 Dallas Street
Houston, Texas 77002
Office: (713) 757-1156
Home: (713) 465-2115

MITCHELL P. ANDERSON
Geologist
Americana Building
811 Dallas, Suite 927
Houston, Texas 77002
(713) 650-3060
Wilcox Oil & Gas, Inc.

Royal Oil & Gas Corporation
Since 1931
M Bank Center
Suite 807 North
500 North Water Street
Corpus Christi, Texas 78471
Wayne S. Croft
District Geologist
Office: (512) 888-4792
Home: (512) 991-7450

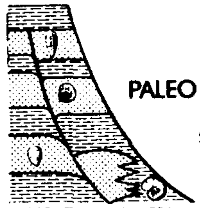
713-774-4091
PETCONS & ASSOCIATES
Petroleum Consultants
8414 Braes Meadow Drive
Houston, Texas 77071
STUART HASTINGS
Chairman

BSE
B & S Exploration, Inc
JAMES B. BENNETT
Geology
RANDALL SCHOTT
Geophysics
1300 Main Street
Third Floor
Houston, Texas 77002
Bus (713) 650-1378

DGSI
WE MAKE GEOCHEMISTRY WORK
WALLACE G. DOW
President
8701 New Trails Drive
The Woodlands, Texas 77381
(713) 363-2176
FAX (713) 292-3528
Telex 881137 DGSI

P.O. Box 441372
Houston, TX 77244-1372
(713) 497-7693
HAROLD V. HILTON
Certified Petroleum Geologist
CPG 1304
Specializing in South Louisiana
EXPLORATION-SEDIMENTATION-PALEO

Tribow Oil And Gas Corp.
BURTON C. BOWEN
President
WILLIAM D. TURNER
Geologist
ROBERT H. FORDE
Geologist
1010 Lamar
Suite 1580
Houston, TX 77002
Telephone
(713) 650-3614



BOB DRAKE
PALEO MARKETING, INC.
5625 NORTH WEST CENTRAL
SUITE D-100
HOUSTON, TEXAS 77092
RESIDENCE 713-466-1251
OFFICE 713-690-4255

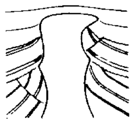
HOLMGREN Exploration & Production, Inc.
DENNIS A. HOLMGREN
CONSULTING GEOLOGIST
OIL AND GAS EXPLORATION
1980 Post Oak Blvd., Suite 1330
Houston, Texas 77056
(713) 840-1980
FAX (713) 840-0135

T. WAYNE CAMPBELL
PALEO-DATA, INC.
CONSULTING PALEONTOLOGIST AND GEOLOGIST
6619 FLEUR De LIS DRIVE
NEW ORLEANS, LOUISIANA 70124
(504) 488-3711

NORTEX CORPORATION
Al W. Dugan, President
Robert W. Kent, Vice President
1415 Louisiana Suite 3100
Houston, Texas 77002
(713) 658-1142
Fax: 658-0739

Hurst Drafting, Inc.
Suite 1900
806 Main Street
Houston, Texas 77002
Melvin F. Hurst
President
(713) 227-5008
(Fax) 227-2143

JACK E. COFFMAN
PRESIDENT
SONORA PETROLEUM CORP.
1201 LOUISIANA, SUITE 3100
HOUSTON, TEXAS 77002
713/659-1044
713/589-2928
TX. P.E. 35812
LA. P.E. 20371

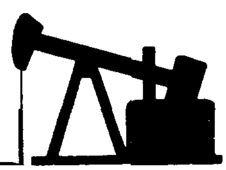


MARK R. ETHEREDGE
Consulting Geologist
U.S. and International
7015 W. Tidwell Rd., Ste. 111-B
Houston, Texas 77092
Off. 939-8243
Hm. 890-1286

TECHNICAL TRANSLATIONS
Spanish - English
ALICIA A. IMERITO
Geologist
9418 Meadowcroft
Houston, Texas 77063
(713) 785-4879

LOUISIANA
TEXAS
JACK COLLE
JACK COLLE & ASSOCIATES
CONSULTING GEOLOGIST & PALEONTOLOGIST
911 WALKER - SUITE 321
HOUSTON, TEXAS 77002
JACK COLLE
713 - 228-8221
RES. 622-9555
J. G. WARD
713 - 228-8221
RES. 457-7298

FAST & ACCURATE REPORTING COMPANY
WEEKLY OIL & GAS REPORT - NEW LOCATIONS, COMPLETIONS & DRLG INFO - SO, NO & OFF LA, MS, ALA & FLA
CALL FOR PRICING
(504) 830-4863
AND RECEIVE FOUR (4) WEEKLY REPORTS FREE FOR MENTIONING AD - SOME RESTRICTIONS APPLY
FREE REPORT!



LARRY L. JONES
PRESIDENT
SPARTAN PETROLEUM CORPORATION
11757 KATY FRWY
SUITE 800
HOUSTON, TEXAS 77079
713/493-1022

"Support those who support our Society."

WLA

WILLIAM A. LAMONT
GEOPHYSICAL CONSULTANT

4923 MAPLE ST.
BELLAIRE, TEXAS 77401
RES: 713-668-0067

William A. Monroe
-Consulting Geologist-

Development Geology
Prospect Evaluation
Houston, Texas

Office 713/961-9970
Residence 713/493-4750

WILLIAM M. SMITH
Geologist

Wilcox Oil & Gas, Inc.

Americana Building
811 Dallas, Suite 927
Houston, Texas 77002
(713) 650-3060

THE RUFE LeBLANC SCHOOL OF CLASTIC SEDIMENTS

Offers several Courses and Field Trips on Recent and Ancient Clastics of Texas, Colorado, Oklahoma and Arkansas

Rufus J. LeBlanc, Sr., Owner
3751 Underwood St., Houston, Texas 77025
(713) 668-5635

CARL M. PADGETT
CONSULTING GEOPHYSICIST

10250 Bissonnet, Suite 326
Houston, Texas 77036
Office (713) 981-7026
Res. (713) 879-0440

LOYD TUTTLE
PCI PALEO CONTROL, INC.
MICROPALEONTOLOGY PALEOECOLOGY

5625 N.W. CENTRAL DR.
SUITE 100
HOUSTON, TEXAS 77092
OFFICE 713-690-4255 RESIDENCE 713-466-7922

TTX
TERTIARY TRENDS EXPLORATION

Tertiary Trends Exploration, Inc.
6217-B Edloe Street
Houston, TX 77005
Telephone: 713-661-4294
Fax: 713-666-2354

ANN AYERS MARTIN

Gas & Oil Properties

Chuck L. Reagan

1937 W. Gray • Suite 200
Houston, Texas 77019
Office: (713) 524-6331
Res: (713) 266-8114
Fax: (713) 524-9132

BARRY K VAN SANDT
PE MBA

VAN SANDT & ASSOCIATES, INC.
Petroleum Engineering Consultants and Financial Analysts

9525 Katy Freeway
Suite 138
Houston, Texas 77024
Off 713 465-3792
Res 713/467-7256

J. DON McCLELLAND
GEOLOGIST

BUSINESS
P.O. BOX 1155
BOERNE TEXAS 78006
TEL 512 249 3522

RESIDENCE
San Antonio 512 698 1266
Boerne 512-755-4535

713/789-4104
FAX 713/467-1785

Cecil R. Rives
PETROLEUM GEOLOGIST

SUITE 360
800 BERING DR
HOUSTON, TEXAS 77057

George F. Watford
—Investments—

(713) 654-1400
Fax 654-1285

880 Citicorp Center
1200 Smith Street
Houston, Texas 77002

R M CONSULTANTS
332 So. Lynchburg Rd.
Baytown, Texas 77520
713-424-1777

OWNER
ROBERT MACKE

CONSULTING PETROLEUM GEOLOGIST

JAMES W. ROACH
PETROLEUM GEOLOGIST

PRESIDENT
JWR EXPLORATION, INC.
2929 BRIARPARK, SUITE 214
HOUSTON, TEXAS 77042
OFF. 713-784-4080
HOME: 782-9704

Telex: RCA 265788 SKRGL UR
FAX: (713) 973-2055
Office: (713) 781-3945
Home: (713) 728-8736

Augustus O. Wilson, Ph.D.
Saker Geological Services

Carbonate Geology
Sedimentary Petrology
Regional Geologic Studies

8610 Harwin
Suite 154
Houston, Texas 77036
U.S.A.

FRANK S. MILLARD

PETROPHYSICAL SERVICES INC.
WELL LOG INTERPRETATIONS-SEMINARS

713/782-8033
10211 HOLLY SPRINGS
HOUSTON, TEXAS 77042

TGS ONSHORE GEOPHYSICAL COMPANY

MARV SAGER
BERT HOYT
TERRY WELPER

333 CLAY SUITE 3900
HOUSTON, TEXAS 77002
713/951 0853

IES

Nelson B. Yoder
(President)
(713) 471-8406
Fax (713) 471-7951

"Specializing in Carbonate Petrography"

INTEGRATED EXPLORATION SERVICES, INC.
P.O. Box 1546 3903 Old Hwy. 146 La Porte, Texas 77572

Cheryl Desforges Miller

Certified Petroleum Geologist 2925
Certified Professional Geologist 4851

(713) 466-7996
16309 Lakeview Drive
Houston, Texas 77040

SHIELD DEVELOPMENT CORPORATION

Oil-Gas-Minerals

ELGEAN C. SHIELD
President

300 Shepherd Suite D
Houston Texas 77007
Bus (713) 861-2010
Res (713) 520-0303

MANUEL ZEGARRA AND ASSOCIATES
Geology–Geophysics
EXPLORATION CONSULTANTS INTERNATIONAL

Extensive Resident Experience in Perú, Venezuela — South America and U.S.A.
(US Dept. of Labor — Cert: TEC JO#4274782)

3233 Windchase Blvd. #902
Houston, Texas 77082
(713) 589-0422
Fax: (713) 782-1572

HUGH E. MURPHY
PETROLEUM GEOLOGIST

ROUTE 2, BOX 770
LIVINGSTON, TEXAS 77351
(409) 646-5971

DOMESTIC FOREIGN

LEO SHISHKEVISH, Ph.D.
STRATCO

MICROPALEONTOLOGY
PALEOECOLOGY
GEOLOGY OF U.S.S.R.

12422 PERTHSHIRE
HOUSTON, TEXAS 77024
(713) 464-4794

MITCHELL ENERGY & DEVELOPMENT CORP.
2001 TIMBERLOCH PLACE
THE WOODLANDS, TEXAS 77380

• EXPLORATION • PRODUCTION • GAS PROCESSING

"Support those who support our Society."

ADVERTISERS

Bulletin Houston Geological Society
7171 HARWIN, SUITE 314
HOUSTON, TEXAS 77036-2190

SECOND CLASS
U.S. POSTAGE
PAID
Houston, Texas