Mountains of Opportunity

2005 Eastern Section
American Association of Petroleum Geologists

34th Annual Meeting

September 18-20, 2005

Radisson Waterfront Hotel and Conference Center
2 Waterfront Place
Morgantown, WV 26501

Hosted by
The Appalachian Geological Society
The West Virginia Geological and Economic Survey

Convention Website: http://www.wvgs.wvnet.edu/www/esaapg05/index.html

Sponsors

We sincerely appreciate the support of the following companies and organizations:

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Meeting Committee and Organizations

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General Chair	Katharine Lee Avary
Program Chair	Michael Ed. Hohn
Field Trip Chair	Ronald McDowell
Workshop Chair	Douglas G. Patchen
Speaker Ready Room &AV Chair	Jim Templin
Registration Chair	Susan Kite
Treasurer	Ed Rothman
Sponsor Chair	Pete Sullivan
Exhibits Chair	Dave Cox
Publicity/Marketing Chair	Jim Templin
Website Chair	John Bocan
Entertainment Chair	Dave Oldham
Spouse Program Chair	B.J. Carney
Hotel Liaison	Douglas G. Patchen
Student Job Quest Chair	B.J. Carney
Judging Chairs	Jane McColloch
	Scott McColloch
Logo and Theme	Denise Hight

Appalachian Geological Society 2005-2006 Officers

President	B.J. Carney
Vice President	Denise Hight
Secretary	Rick Sircy
Treasurer	Jim Templin

Eastern Section AAPG

Executive Committee

President	Murray Matson
Vice President	Pete MacKenzie
Secretary	Jim Drahovzal
Treasurer	Dan Billman
Advisory Council Rep.	Katharine Lee Avary

Other Officers

Archivist	Brian D. Keith
Webmaster	Michael Hohn

Councilors

EMD Councilor	Douglas G. Patchen
DEG Councilor	Hannes E. Leetaru
DPA Advisory Board	Michael R. Canich

Committee Chairs

Honors and Awards	Jeff Greenawalt
Membership	John L. Forman
Nominations	Steven P. Zody
Earth Science Outreach	Pete MacKenzie
Future Meetings	Hannes E. Leetaru
	David Morse

Schedule of Events

Friday, 16 September 2005

3:00 pm	Field Trip 1 departs (*Ticketed Event)*	Morgantown Airport

Saturday, 17 September 2005

7:30 am to 5:00 pm	Well Log Analysis Workshop (*Registration with AAPG*)	Waterfront A&B
6:00 pm to 8:00 pm	Student Job Quest Reception and Poster Session	Foyer

Sunday, 18 September 2005

8:00 am to 5:00 pm	Registration	Boulevard Entrance
8:00 am to 5:00 pm	Meeting Office open	Boardroom
8:00 am to 2:00 pm	Exhibit Hall set up	Grand Ballroom D&E
8:00 am to 5:00 pm	Well Log Analysis Workshop	Waterfront A&B
9:00 am to 2:00 pm	Student Job Quest Posters	Foyer
9:00 am to 2:00 pm	Student Job Quest Interviews	Riverfront Terrace
1:00 pm to 5:00 pm	Presentation Center & Judges' Room open	Boardroom
2:00 pm to 5:00 pm	Opening Session & Awards Ceremony	Grand Ballroom A-C
5:00 pm to 8:00 pm	Exhibit Hall open	Grand Ballroom D&E
5:00 pm to 8:00 pm	Icebreaker Reception	Grand Ballroom D&E

Monday, 19 September 2005

7:00 am to 8:30 am	Speakers', Poster Presenters' & Judges' Breakfast	Waterfront A&B
7:00 am to 8:30 am	House of Delegates Breakfast (*by invitation*)	Wharf A&B
7:00 am to 5:00 pm	Registration	Boulevard Entrance
8:00 am to 5:00 pm	Meeting Office open	Boardroom
8:00 am to 5:00 pm	Presentation Center & Judges' Room open	Boardroom
8:00 am to 6:00 pm	Exhibit Hall open	Grand Ballroom D&E
8:30 am to Noon	Technical Session No. 1	Grand Ballroom A-C
8:30 am to Noon	Technical Session No. 2	Grand Ballroom F-H
9:00 am to 5:00 pm	Poster Session No. 1	Foyer
Noon to 1:30 pm	Eastern Section Council Business Luncheon (*by invitation*)	Wharf A&B
1:30 pm to 5:00 pm	Technical Session No. 3	Grand Ballroom A-C
1:30 pm to 5:00 pm	Technical Session No. 4	Grand Ballroom F-H
5:00 pm to 6:00 pm	Mini-Breaker Reception	Grand Ballroom D&E

Tuesday, 20 September 2005

7:00 am to 8:30 am	Speakers', Poster Presenters' & Judges' Breakfast	Waterfront A&B
7:00 am to 8:30 am	Eastern Section Future Meetings Committee Bkfst	Wharf A&B
7:00 am to 5:00 pm	Registration	Boulevard Entrance
8:00 am to 5:00 pm	Meeting Office open	Boardroom
8:00 am to 5:00 pm	Presentation Center & Judges' Room open	Boardroom
8:00 am to 4:00 pm	Exhibit Hall open	Grand Ballroom D&E
8:30 am to Noon	Technical Session No. 5	Grand Ballroom A-C
8:30 am to Noon	Technical Session No. 6	Grand Ballroom F-H
9:00 am to 4:00 pm	Poster Session No. 2	Foyer
Noon to 1:30 pm	All-Division Luncheon (*Ticketed Event)*	Wharf A&B
1:30 pm to 5:00 pm	Technical Session No. 7	Grand Ballroom A-C
1:30 pm to 5:00 pm	Technical Session No. 8	Grand Ballroom F-H
4:00 pm	Field Trip No. 2 departs (*Ticketed Event)*	Lobby Entrance

Wednesday, 21 September 2005

7:30 am to noon	Registration for workshop	Foyer
8:00 am to 5:00 pm	Rocks to Models Workshop (*Ticketed Event)*	Waterfront A&B

General Information

On-Site Registration takes place in the Foyer off the Lobby. The hours are:

Sunday September 18 8:00 am to 5:00 pm
Monday September 19 7:00 am to 5:00 pm
Tuesday September 20 7:00 am to 5:00 pm

Exhibit Hall hours are:

Sunday September 18 5:00 to 8:00 pm
Monday September 19 8:00 am to 6:00 pm
Tuesday September 20 8:00 am to 4:00 pm

Speakers, Poster Presenters, and Session Chairs should attend the breakfast the day of their presentation in Waterfront A & B to receive final instructions.

All **judges** are invited to attend a complimentary breakfast on the morning they are judging, from 7:00 a.m. to 8:30 a.m. in the Waterfront A and B, to pick up judges' packets and receive final instructions. The judges' room is the Boardroom, where you may drop off your completed forms. If you are unable to attend the breakfast, please stop by the Boardroom to pick up your packet or see Jane McColloch.

Please Consider Being a Judge!
Your assistance in judging oral and poster presentations at the 2005 ES-AAPG Meeting is requested! The judging process is essential to the success of the technical awards program. This important function will determine the winners of the following technical awards: A. I. Levorsen Memorial Best Paper Award; Vincent E. Nelson Memorial Best Poster Award; Margaret Hawn Mirabile Memorial Best Student Paper Award; and Division of Environmental Geosciences (Eastern Section) and Energy Minerals Division (Eastern Section) best paper and poster awards. Your effort will involve judging and evaluating one oral or poster session. Judging instructions and forms will be provided to you during a **complimentary** Judges Breakfast on the day of your session.

To volunteer to be a judge, please contact Judging Chairperson Jane McColloch at (304) 594-2331 ext. 425 or by e-mail at janemc@geosrv.wvnet.edu, or mark the judging box on your registration form. Thank you!

We ask that cell phones be silenced in all meeting rooms.

A no smoking policy is in effect for all meeting rooms and public areas in the hotel.

Exhibitors

PRJ, Inc.
Neuralog, Inc.
Landmark Graphics-GeoGraphix
GeoSearch Logging, Inc.
GAPS-Geophysical Applications, Inc.
AAPG Bookstore
BJ Services
Allegheny Wireline/Precision
GeoCare Group Benefits/AGIA
Direct Geochemical
Midwest PTTC
Appalachian PTTC
NETL/U.S. Department of Energy
Rockware

Special Events

Student Job Quest

Saturday and Sunday, 17-18 September

Students, are you looking for a summer internship or full-time employment after graduation? Or, are you just curious about employment opportunities in the oil and gas, coal, environmental or geotechnical engineering industries? Employers, are you looking for summer interns or full-time employees?

If so, you need to be in Morgantown on September 17 and 18. On Saturday evening, there will be a reception, poster session, and networking opportunity. Sunday morning, students will have the opportunity to meet company representatives. Potential employers from oil and gas, coal, environmental or geo-technical engineering companies are invited to participate in the Job Quest. Employers who want to participate in the Job Quest can receive registration materials from the website or by contacting Katharine Lee Avary, 304/594-2331 avary@geosrv.wvnet.edu, or B.J. Carney, bjcarney@trianaenergy.com and 304-353-5211.

Cost: Included with registration for students.

AAPG Leadership Technical Session

When you see the national AAPG officers huddled in conference at an Eastern Section meeting do you think of them as working geologists, just like you? When you listen to the national and division Presidents address the Opening Session, do you think they have more to offer than just a summary of AAPG business items within their personal domains? Do you consider them to be approachable, so that you could ask technical questions that perhaps they could answer, based on their vast cumulative experience in the US and elsewhere? Well, plan to attend the special technical session on Monday morning, September 19th to find out. The local organizing committee is pleased to announce that a first-of-its-kind special technical session will be offered, during which AAPG leaders – Executive Committee members and all three Division Presidents – will present technical papers on a variety of topics, all of which will contain important lessons for geologists in our section. Please plan to attend this special session to listen to these papers, ask questions after the talks, and use the experience to communicate with your leaders on a geologist-to-geologist level.

Opening Session and Awards

Sunday, 18 September 2:00 – 5:00 pm

The traditional Opening Session and Awards Ceremony is an opportunity for AAPG members in the Eastern Section to meet their Eastern Section and National officers and officer candidates, and to honor those among you who have distinguished themselves through their service to AAPG or through technical presentations at the previous Eastern Section meeting in Columbus. Please arrange your travel plans to support these leaders and honorees with your attendance. **The Eastern Section should be proud of this session, which is by far the best of its kind in any AAPG domestic section.**

Once again, the Opening Session will kick off the annual meeting, culminating with the recognition of AAPG's top eastern dignitaries for 2004-05. General Chairperson Katharine Lee Avary will preside over the Opening Session, which will include brief remarks from regional and national AAPG officers.

Once the section and national officers and candidates have been introduced, it will be time to recognize and honor the AAPG Eastern Section Awardees. Special awards will be presented to these outstanding recipients, culminating in the Keynote address by Robert Milici, this year's John T. Galey Memorial Award recipient.

Immediately following the awards ceremony, the traditional Icebreaker Reception will be held in the Exhibit Hall, giving you a chance to meet the awardees and officers, greet old friends and officially begin to enjoy the flavor of the newly refurbished and revitalized Wharf District of Morgantown.

Cost: Included with registration.

Icebreaker Reception

Sunday, 18 September 5:00 – 8:00 pm

Meet your friends and colleagues from around the region at the traditional Icebreaker and celebrate the opening of the Exhibit Hall. This combination social/business event will be an excellent opportunity for you to view and assess the exhibits while enjoying food and drink dispersed at stations and cash bars throughout the hall. Admission is by registration badge only.

Cost: Included with registration.

Mini-Breaker Reception

Monday, 19 September 5:00 – 6:00 pm

Another opportunity to combine business and pleasure, the very popular Mini-Breaker will be held in the Exhibit Hall. We invite you to enjoy snacks and refreshments as you visit the exhibits after the oral sessions end on Monday. Admission is by registration badge only.

Cost: Included with registration.

All-Division Luncheon

Tuesday, 20 September noon - 1:30

The Appalachian Geological Society and the Eastern Section AAPG are pleased to welcome **Dr. Ian Duncan**, Associate Director for Earth and Environmental Systems at the Texas Bureau of Economic Geology as the featured speaker at the All-Division (EMD, DPA, DEG) luncheon. Luncheon activities will begin at noon and conclude by 1:30 in time for participants to attend the afternoon technical sessions. Dr. Duncan's address will be a logical supplement to our technical program, which has a strong CO_2 sequestration component. In particular, Dr. Duncan will focus on the value-added aspect of CO_2 sequestration, i.e., combining CO_2 sequestration with enhanced oil recovery projects, particularly in areas outside of West Texas where a natural CO_2 pipeline is in operation.

"CO_2 EOR: New Economic Drivers and New Strategies"

"Can capture of CO_2 from power plants and refineries enable EOR outside the Permian basin of West Texas? Higher oil prices, new lower cost capture technologies, new EOR strategies and possible credits for CO_2 sequestration are driving interest in possible CO_2 EOR projects outside the Permian basin of Texas, beyond the reach of natural CO_2 pipelines. Can new approaches to CO_2 EOR lower capital costs while at the same time increasing the recovery efficiency of oil in place?"

Cost: $30
Limit: 50 persons

Spouse and Guest Activities

Spouse/Guest Hospitality Suite at the Radisson Waterfront Hotel and Conference Center Monday and Tuesday, September 19 and 20, 2005. Coffee, tea, pastries, 8-10 AM each day. Check with ES AAPG meeting registration desk for location. Information on local attractions will be available.

Visit to Seneca Center for shopping and lunch at the Glasshouse Grille Monday, September 19, 2005, 10 AM to 2 PM, transportation provided.
http://www.senecacenter.com/
http://www.theglasshousegrille.com/

Visit to ZenClay pottery gallery and lunch Tuesday, September 20, 2005, 10 AM to 2 PM, transportation provided.
http://www.zenclay.com/

Radisson Waterfront Spa and Salon A full-service spa and salon is located within the hotel.

Self-guided walking tour of downtown Morgantown
http://www.downtownmorgantown.com/pages/audio-tour.htm
Equipment and brochure can be picked up at the Greater Morgantown Convention and Visitors' Center - 201 High Street. Hours are Monday-Friday 9:00 AM - 5:00 PM; Saturday 10:00 AM - 4:00 PM; Sunday Noon-4:00 PM The audio portion is about 60 minutes, but will take longer than an hour to walk the tour. For more information call the visitor's center at 1-800-458-7373. Cost is $ 8.00 per person, $12.00 for a couple. and $5.00 per person for groups of 3 or more. A major Credit Card must be available as they will charge a card if equipment is not returned. There is a limit of 4 hours (unless other arrangements are made) for the return of the equipment.

Local Events

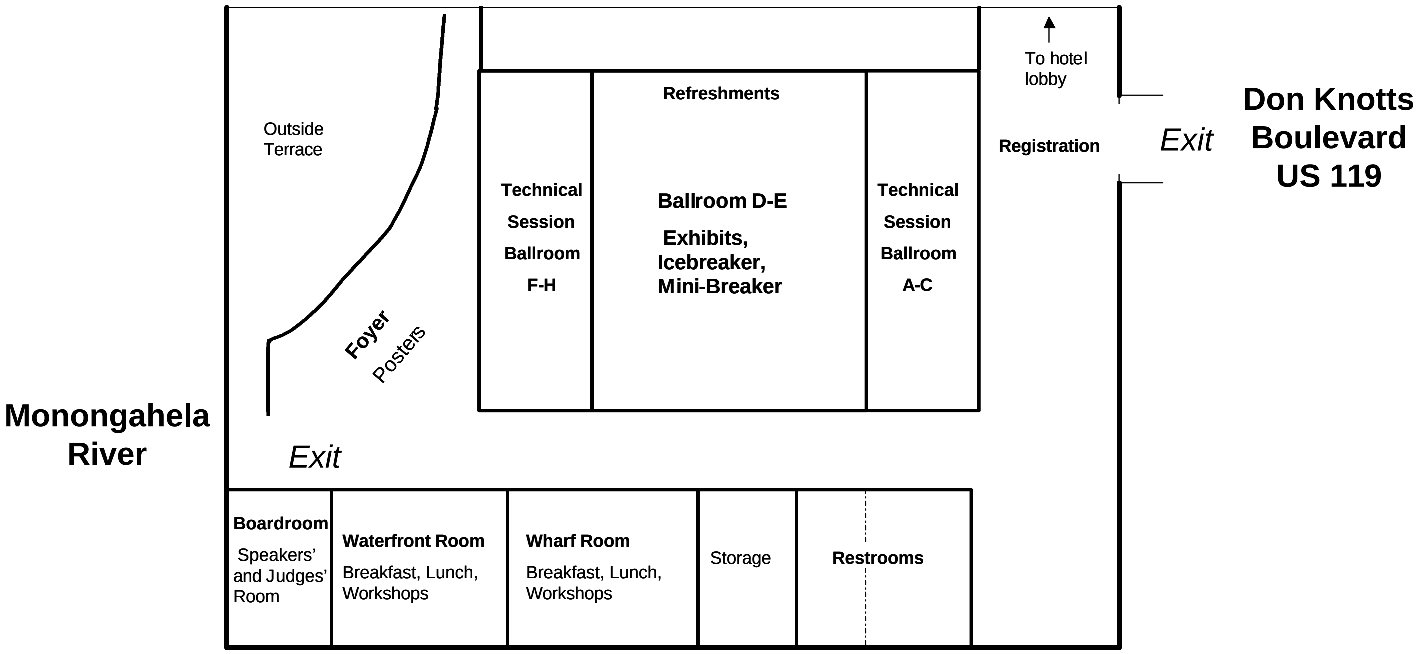
For those arriving Saturday or Sunday, there are several festivals in the immediate area:

Fourteenth Annual Cheat Lake Gem, Mineral and Fossil Show Saturday-Sunday, September 17-18, 2005, at West Virginia Geological and Economic Survey, Research Center at Mont Chateau, 1 Mont Chateau Road, Cheat Lake, Exit 10 off Interstate 68, east of Morgantown, West Virginia. Hours are: September 17 (10:00 AM - 6:00 PM) and 18 (11:00 AM - 5:00 PM) http://www.wvgs.wvnet.edu/www/news/goedgems.htm

Florence Merow Mason- Dixon Festival Friday-Sunday, September 16-18, 2005, , Hazel Ruby McQuain Riverfront Park. Celebrate mountain heritage and history at the 19th year of the Florence Merow Mason-Dixon Festival of WV along the banks of the Monongahela River, at the Hazel Ruby McQuain Amphitheatre. There will be food, vendors, a talent show, baking contest and fireworks as well as arts, crafts and live entertainment. There is no charge for admission. Hours are: Friday-5:30 p.m. to 10 p.m., Saturday- 11 a.m. to noon, Sunday-12 noon to 8.
p.m. http://www.masondixonfest.com

Saturday-Sunday, September 17-18, 2005, Wine and Jazz Festival, Camp Muffly, I-79, Exit #146, Goshen Rd. Featured will be West Virginia Wineries, live jazz, gourmet food, artisans and more. Valid I.D. required for wine tasting. Call (304) 292-WINE for more information. Hours are: Saturday- 11 a.m. to 6 p.m. and Sunday- Noon to 6 p.m.

Radisson Waterfront Conference Center, Morgantown, WV



Opening Session and Awards

Sunday, 18 September 2005
2:00 – 5:00 pm Grand Ballroom A-C

Katharine Lee Avary, Presiding

Welcoming Remarks

2:00 .... Katharine Lee Avary - General Chair

2:10 .... Murray Matson - President of Eastern Section, AAPG

Comments from National AAPG Guests

2:20 .... Deborah K. Sacrey – President, Division of Professional Affairs

2:30 .... Steven P. Tischer – President, Division of Environmental Geosciences

2:40 .... Peter Warwick – President, Energy Minerals Division

2:50 .... Rick Fritz – AAPG Executive Director

3:00 .... Peter R. Rose – AAPG President
Remarks
Introduction of Officer Candidates

Honors and Awards Ceremony

3:30 .... Jeff Greenawalt, Presiding
4:30 .... John T. Galey Memorial Address: Robert C. Milici
Fractures Related to Limited Décollement, the Porous Fracture Facies of Shumaker - a Review

Honors and Awards

Eastern Section Earth Science Teacher Award
Carol Muniz
Division of Environmental Geosciences Best Poster Award
Jason Witter
Division of Environmental Geosciences Best Paper Award
Dr. James A. Drahovzal
Ralph L. Miller Best Energy Minerals Division Paper Award
Ernie R. Slucher
Vincent E. Nelson Memorial Best Poster Award
Scott Brame
Margaret Hawn Mirabile Memorial Best Student Paper Award
Sean Cornell
A.I. Levorsen Memorial Award
Dr. Langhorne "Taury" B. Smith
Gordon H. Wood, Jr. Memorial Award (Eastern Section EMD)
Dr. C. Blaine Cecil
Outstanding Educator Award
Dr. J. Fred Read and Dr. Peter J.R. Buttner
George V. Cohee Public Service Award
Brandon C. Nuttall
Distinguished Service Award
Michael R. Canich and Steven P. Zody
Honorary Membership Award
David C. Harris
John T. Galey Memorial Award
Dr. Robert C. Milici

Technical Program

Monday Morning Oral

Special Session: AAPG Leaders Speak to Members

Grand Ballroom A-C
Douglas G. Patchen and Katharine Lee Avary, Session Chairs

8:20 **Introductory Remarks**

8:30 **Oil and Gas Reserves Estimating – We Have Met the Enemy, and He is Us**
Peter R. Rose, Rose Associates

9:00 **Challenging Prospects: the Hunt for Oil and Gas in the Bavarian Alps of Germany**
Stephen L. Veal, DCX Resources

9:30 **Geology 101: the Discovery of the Billy (ABO) Field, Lamb County, Texas**
J. Michael Party, Wagner & Brown, Ltd

10:00 **Oil Development in an Urban Environment: Los Angeles, an Example for the Entire World**
Donald D. Clarke, Consulting Geologist

10:30 **Workstation 101 and How to Find Consulting Work**
Deborah K. Sacrey, Auburn Energy

11:00 **Cretaceous and Tertiary Coal-Bed Gas Resources in the Gulf of Mexico Coastal Plain**
Peter Warwick, US Geological Survey

11:30 **Treatment of a Chromate-impacted Water-bearing Unit in Ogallala Sediments, Southern Lea County, New Mexico**
Steven P. Tischer, ARCADIS

DEG/EMD: Carbon Sequestration I

Grand Ballroom F-H
J.A. Drahovzal and L.H. Wickstrom, Session Chairs

8:30 **Geologic CO_2 Sequestration – An Introduction**
L.H. Wickstrom, Ohio Geological Survey

9:00 **Siting Coal-Fired Power Plants in a Carbon-Managed Future: the Importance of Geologic Sequestration Reservoirs**
S.F.Greb, B.C.Nuttall, M.P. Solis, T.M. Parris, J.A. Drahovzal, C.F. Eble, D.C. Harris, J.B. Hickman, P.D. Lake, B. Overfield, and K.G. Takacs, Kentucky Geological Survey

9:30 **The Effects of CO_2 Interaction with Coal**
Ryan N. Favors, National Energy Technology Laboratory, U.S. Department of Energy, Pittsburgh, PA and Purdue University, Chemistry Department, and Angela L. Goodman, National Energy Technology Laboratory, U.S Department of Energy

10:00 **Improved Understanding of Regional Geologic CO_2 Storage Options through Collaboration with Oil and Gas Industry**
Neeraj Gupta, Phil Jagucki, and Joel Sminchak, Battelle, and Charles Byrer, National Energy Technology Laboratory

10:30 **Volume Fraction Analysis of Two-Phase Flows in Fractures**
Dustin Crandall, Clarkson University, Mechanical and Aeronautical Engineering Department, Goodarz Ahmadi, Clarkson University, Mechanical and Aeronautical Engineering Department,Grant Bromhal, National Energy Technology Laboratory, U.S. Department of Energy and Duane Smith, National Energy Technology Laboratory, U.S. Department of Energy

11:00 **Investigation of Brine Geochemistry and Implications for Geologic Sequestration of CO_2 in Deep Sedimentary Basins**
Bruce Sass, Neeraj Gupta, Phil Jagucki, and Joel Sminchak, Battelle, Columbus, Ohio, John Massey-Norton, American Electric Power, and Frank Spane, Pacific Northwest National Laboratory

11:30 **Potential Carbon Sequestration Targets in Saline Reservoirs of Kentucky**
James A. Drahovzal, David C. Harris, Brandon C. Nuttall, Michael P. Solis, and Stephen F. Greb, Kentucky Geological Survey

Monday Afternoon Oral

Reservoir Management and Technology

Grand Ballroom A-C
Ray M. Boswell and Dan Billman, Session Chairs

1:30 **Developing New Advances in 3D Seismic Interpretation Methods for Fractured Tight Gas Reservoirs**
James J. Reeves, GeoSpectrum, Inc.

2:00 **Case Histories: Frac Fluid Recovery Improvements of Appalachian Basin Tight Gas Reservoirs**
Javad Paktinat, Bill Stoner, Curt Williams, and Joe Pinkhouse, Universal Well Services

2:30 **Geology and Geometry, A Geological Perspective on Maximizing Performance of Hydraulic Fractures**
Roger Willis, Universal Well Services, Inc., Charles Moyer, Great Lakes Energy Partners, and Jim Fontaine, Universal Well Services, Inc.

3:00 **Break**

3:30 **Geochemical Exploration For Trenton-Black River Gas Reservoirs In New York and Ohio**
David M. Seneshen, James H. Viellenave and John V. Fontana, Direct Geochemical

4:00 **Porosity Evaluation of the Geneva Dolomite (Marion County, Illinois) Using Petrophysical Data**
B. R. Summers and P. J. Carpenter, Northern Illinois University

4:30 **Intelligent Seismic Inversion: From Surface Seismic to Well Logs via VSP**
Emre Artun, Shahab D. Mohaghegh, Jaime Toro, Tom Wilson, West Virginia University, and Alejandro Sanchez, Anadarko Petroleum Corporation

DEG/EMD Carbon Sequestration II

Grand Ballroom F-H
J.A. Drahovzal and L.H. Wickstrom, Session Chairs

1:30 **CO_2 Sequestration in Gas Shales of Kentucky**
Brandon C. Nuttall, James A. Drahovzal, Cortland F. Eble, and R. Marc Bustin, Kentucky Geological Survey

2:00 **Characterization of America's "Engine Room" for Geologic CO_2 Sequestration**
Erik R.Venteris, Ohio Division of Geological Survey, James McDonald, Ohio Division of Geological Survey, Michael P. Solis, Kentucky Geological Survey, University of Kentucky, David A. Barnes, Department of Geosciences, Western Michigan University, Kristen Carter, Pennsylvania Geological Survey, Catherine Lockhart, Maryland Geological Survey, Premkrishnan Radhakrishnan, Indiana Geological Survey, Indiana University, Katharine Lee Avary, West Virginia Geological and Economic Survey

2:30 **CO_2 Sequestration-Assisted Enhanced Hydrocarbon Recovery Potential In The Midwest Regional Carbon Sequestration Partnership**
William B. Harrison, III, Department of Geosciences, Western Michigan University, Katharine Lee Avary, West Virginia Geological and Economic Survey, Gerald R. Baum, Maryland Geological Survey, Brandon C. Nuttall, Kentucky Geological Survey, University of Kentucky, John A. Harper, Pennsylvania Geological Survey, John A. Rupp, Indiana Geological Survey, Lawrence H. Wickstrom, Ohio Geological Survey, William A. Williams, and Richard A. Winschel, CONSOL Energy, Inc.

3:00 **Break**

Petroleum Geology I

Grand Ballroom F-H
Langhorne B. Smith and Thomas Mroz, Session Chairs

3:30 **A Reevaluation of the Silurian Burnt Bluff Group, Michigan Basin through Sedimentologic and Paleoecologic analysis**
P.J.Voice, Virginia Tech University, W.B. Harrison III, and G.M. Grammer, Western Michigan University and the Michigan Basin Core Research Laboratory

4:00 **Outcrop Analog For Lower Paleozoic Hydrothermal Dolomite Reservoirs, Mohawk Valley, New York**
Richard Nyahay, Brian Slater, and Langhorne B. Smith, Reservoir Characterization Group, New York State Museum

Monday Poster

Foyer
9am - 5 pm; Authors present 10am - 12pm and 2pm - 4pm

The Upper Devonian Dunkirk Shale – A Late Hydrocarbon Generator
David R. Blood, Dept. of Geology, University at Buffalo, Buffalo, NY and Gary G. Lash, Dept. of Geosciences, SUNY-Fredonia

Thermal History of the Central and Southern Appalachians from Apatite and Zircon Fission-Track Analysis
Charles W. Naeser, Nancy D. Naeser, and C. Scott Southworth, U.S. Geological Survey

Burial and Thermal History Models of the Central Appalachian Basin, Ohio, Pennsylvania, and West Virginia
E.L. Rowan, R.T. Ryder, J. E. Repetski, M. H. Trippi, and L. F. Ruppert, U.S. Geological Survey

Geologic Cross Section through the Appalachian Basin from Sandusky County, Ohio, to Hardy County, West Virginia
Robert D. Crangle, Jr., Robert T. Ryder, Michael H. Trippi, Christopher S. Swezey, Erika E. Lentz, Elisabeth L. Rowan, and Rebecca S. Hope, U.S. Geological Survey

In Search of a Silurian Petroleum System in the Central Appalachian Basin
R.T. Ryder, E.E. Lentz, M.H. Trippi, U.S. Geological Survey, K.L. Avary, West Virginia Geological Survey, J.A. Harper, Pennsylvania Geological Survey, W.M. Kappel, U.S.Geological Survey, and R.G. Rea, Ohio Geological Survey

Coalbed Methane Research Drilling in Illinois- New Data
David G. Morse, Ilham Demir, Thomas R. Moore, and Scott D. Elrick, Illinois State Geological Survey

A Basin-Wide Geologic Resource Assessment of the Upper Devonian Interval in the Appalachian basin
Ashley S.B. Douds, EG&G-NETL, James A. Pancake, EG&G-NETL, and Ray M. Boswell, U.S. Dept. of Energy-NETL

Treating Natural Gas Storage Produced Waters Using Constructed Wetland Treatment Systems
Brenda M. Johnson, Clemson University, Department of Forestry and Natural Resources, Laura E. Ober, Clemson University, Department of Geological Sciences, James W. Castle, Clemson University, Department of Geological Sciences, and John H. Rodgers, Jr., Clemson University, Department of Forestry and Natural Resources

The Influence of Cryptic Lineaments upon Patterns of Iron Mineralization, Appalachian Plateau, Western Pennsylvania
Paul R. Coyle, Coyle Geological Services, and Thomas H. Anderson, Department of Geology and Planetary Science, University of Pittsburgh

Western Kentucky Precambrian Structure Map
M.P. Solis, J.A. Drahovzal, S.F. Greb, and J.B. Hickman, Kentucky Geological Survey, University of Kentucky

Tuesday Morning Oral

Petroleum Systems of Appalachian Basin I

Grand Ballroom A-C
Elisabeth L. Rowan and Christopher S. Swezey, Session Chairs

8:30 **Possible Hydrothermal Dolomite Reservoir(s) in the Swan Creek Field, Tennessee**
Jeffrey R. Bailey, Tengasco, Inc., Jonathan C. Evenick, Robert D. Hatcher, Jr., Department of Earth and Planetary Sciences, University of Tennessee, and H. Virginia Weyland, U.S. Department of Energy, National Petroleum Technology Office

9:00 **Wrench Fault Architecture of Trenton Black River Hydrothermal Dolomite Reservoirs**
Langhorne B. Smith and Richard E. Nyahay, Reservoir Characterization Group, New York State Museum

9:30 **Multi-trace Curvature and Rotation Attributes-Application to Fractured and Hydrothermally Altered Reservoirs**
Charlotte Sullivan and Kurt Marfurt, Allied Geophysical Labs, University of Houston

10:00 **Pre–Chattanooga (Devonian-Mississippian Black Shale) Structure and Nashville (Trenton)-Stones River (Black River) Hydrocarbon Production in Tennessee, Kentucky, and Southwestern Virginia**
Robert D. Hatcher, Jr., Jonathan C. Evenick, Department of Earth and Planetary Sciences, University of Tennessee–Knoxville, and H. Virginia Weyland, U.S. Department of Energy, National Petroleum Technology Office

10:30 **The Sevier-Knox/Trenton Total Petroleum System (Hypothetical)**
Robert C. Milici and Robert T. Ryder, U.S. Geological Survey

11:00 **Petrophysics of Medina and Tuscarora Sandstones and Integration with the Tectonic-Stratigraphic Framework, Appalachian Basin, U.S.A.**
James W. Castle, Clemson University, Department of Geological Sciences, and Alan P. Byrnes, Kansas Geological Survey

11:30 **Gas Capillary Sealing as a Mechanism of Seal Development in the Upper Devonian Dunkirk Shale, Western New York State**
Gary G. Lash, Dept. of Geosciences, SUNY-Fredonia

DEG: Environmental Issues, Geology, and Geochemistry

Grand Ballroom F-H
Jane S. McColloch and Ronald R. McDowell, Session Chairs

8:30 **Elevated Barium Levels in Bedrock, Eastern West Virginia: Cause for Alarm?**
Ronald R. McDowell, Katharine L. Avary, and Jane S. McColloch; West Virginia Geological and Economic Survey

9:00 **The Appalachian Salina Deposits: Salt, Industry and Geologists**
Kevin D. Svitana, Department of Geological Sciences, The Ohio State University

9:30 **Using Normalized Residual Polarization (NRP) Analysis of Ground Penetrating Radar Data to Detect Jet Propellant in Soils**
Thomas E. Jordan, University at Buffalo Department of Geology, Gregory S. Baker, University at Buffalo Department of Geology, Keith Henn, Tetra Tech NUS, and Jean-Pierre Messier, United States Coast Guard Support Center

10:00 **Managing Environmental Risks Associated with Gas Production in the Vicinity of Suburban and Rural Development**
James H. Viellenave, John V. Fontana, and David M. Seneshen, ESN Rocky Mountain

10:30 ***Break***

Petroleum Geology II

Grand Ballroom F-H
James Q. Britton and John M. Bocan, Session Chairs

11:00 **Kentucky's Online Geologic Map and Information System**
G.A.Weisenfluh, D.C. Curl, and M.M.Crawford, Kentucky Geological Survey, University of Kentucky

11:30 **Petroleum Potential for the Lower Paleozoic Strata in the Illinois Basin**
Beverly Seyler, John P. Grube, Joan E. Crockett, Philip M. Johanek, Bryan G. Huff, Rex A. Knepp, Steven R. Gustison, and Randy D. Lipking, Illinois State Geological Survey

Tuesday Afternoon Oral

Petroleum Systems of Appalachian Basin II

Grand Ballroom A-C
Elisabeth L. Rowan and Christopher S. Swezey, Session Chairs

1:30 **Economic Deposits of Microbial Methane in Upper Devonian Fractured Black Shales**
Jennifer C. McIntosh, Johns Hopkins University, Morton K. Blaustein Department of Earth and Planetary Sciences, Anna M. Martini, Amherst College, Department of Geology, Lynn M. Walter, University of Michigan, Department of Geological Sciences, Steven T. Petsch, University of Massachusetts-Amherst, Department of Geosciences, and Klaus Nüsslein, University of Massachusetts-Amherst, Department of Microbiology

2:00 ***Roundtable Discussion:* Future Research Directions in the Appalachian Basin**
James L. Coleman, U.S. Geological Survey

2:30 ***Break***

EMD: Coal and Coalbed Methane

Grand Ballroom A-C
Nick Fedorko and B. M. Blake, Session Chairs

3:00 **Illinois Basin Coalbed Gas: Is There a Play?**
Thomas R. Moore, Ilham Demir, and David G. Morse, Illinois State Geological Survey

3:30 **Coal Washability Data Trends in Eastern Kentucky**
B.L. Overfield, G.A. Weisenfluh, and C.F. Eble, Kentucky Geological Survey, University of Kentucky

4:00 **Creating an Integrated Coal Geology and Coal Mining Geographic Information System in West Virginia.**
Nick Fedorko and James Q. Britton*, West Virginia Geological and Economic Survey

4:30 **Thirty Years of Coal Production in West Virginia "Energy Crisis" to Present.**
Gayle H. McColloch, Jr., West Virginia Geological and Economic Survey

**speaker*

Petroleum Geology Iii

Grand Ballroom F-H

Edward M. Rothman and William Harrison, III, Session Chairs

1:30 **Recent Appalachian Basin Mergers and Acquisitions**
Timothy Knobloch, James Engineering, Inc.

2:00 **Outcrop Analogs and Sequence Stratigraphic Context of the First Cow Run Sandstone, (Late Pennsylvanian, Missourian), St. Mary's and Newell Run Oilfields, West Virginia and Ohio**
Ronald L. Martino and Donny Wehrle, Marshall University

2:30 ***Break***

3:00 **Greenhouse, Transitional and Icehouse Eustasy Yield Distinctive Parasequence and Sequence Stacking on Carbonate Platforms**
J. Fred Read, Virginia Tech

3:30 **A GIS Based Sequence Stratigraphic Analysis of the Mississippian Big Lime, West Virginia, U.S.A**
Thomas C. Wynn, Dept. of Geology and Physics, Lock Haven University, and J. Fred Read, Department of Geosciences, Virginia Tech

4:00 **A Basin-wide Geologic Resource Assessment of the Upper Devonian Interval in the Appalachian Basin**
Ashley S.B. Douds, EG&G-NETL, James A. Pancake, EG&G-NETL, and Ray M. Boswell, U.S. Dept. of Energy-NETL

4:30 **Increasing the Value of 2-D Seismic Data through Application to Development Drilling**
B.J. Carney, Columbia Natural Resources, LLC.

Tuesday Poster

Foyer

9am - 4pm; Authors present 10am - 12pm and 2pm - 4pm

Site Selection for Carbon Sequestration in Saline Reservoirs
H.E. Leetaru, Illinois State Geological Survey, S.M. Frailey, Illinois State Geological Survey, D.G. Morse, Illinois State Geological Survey, R.J. Finley, Illinois State Geological Survey, C.P. Korose, Illinois State Geological Survey and, J.H. McBride, Brigham Young University

Assessing Carbon Sequestration Potential for "Unmineable" Coal Beds in Eastern Kentucky
S.F. Greb, G. A.Weisenfluh, and C.F. Eble, Kentucky Geological Survey, University of Kentucky

Sequestration Potential in the Illinois Basin Coal Beds
Agnieszka Drobniak, Indiana Geological Survey, Christopher Korose, Illinois State Geological Survey, Maria Mastalerz, Indiana Geological Survey, Thomas R. Moore, Illinois State Geological Survey, and John Rupp, Indiana Geological Survey

A Multi-Disciplinary Approach for Mapping Rock Units with Geologic Carbon Sequestration Potential
Kristin M. Carter, Pennsylvania Department of Conservation and Natural Resources, Bureau of Topographic & Geologic Survey, and Erik R. Venteris, Ohio Division of Geologic Survey

Fracture Pattern Analysis using FMI Logs of the Tensleep Formation, Teapot Dome, Wyoming
Bryan C. Schwartz, Department of Energy, National Energy Technology Laboratory and West Virginia University, Department of Geology and Geography, Thomas H. Wilson Department of Energy, National Energy Technology Laboratory and West Virginia University, Department of Geology and Geography, and Duane H. Smith, Department of Energy, National Energy Technology Laboratory

New Model for Characterizing a Shallow Bedrock Aquifer in Central Lower Michigan- Heterogeneity and Discontinuity Dominates the System.
Niah Venable and Dave Barnes, Department of Geosciences, Western Michigan University

Oil Field Structural Mapping and the Distribution of Dolomite in the Dundee Formation in Michigan
David A. Barnes, G. Michael Grammer, William B. Harrison III, Robb Gillespie, Joshua Stewart, Amanda Wahr, and Joshua Kirshner, Department of Geosciences, Western Michigan University

Evaluating Controls on the Formation and Reservoir Architecture of Niagaran Pinnacle Reefs (Silurian) in the Michigan Basin: A Sequence Stratigraphic Approach
A.E.Sandomierski, G.M.Grammer, and W.B. Harrison III, Carbonate Sedimentology Laboratory, Western Michigan University

Analogs for Fault-Controlled Ordovician Dolomite Reservoirs, Appalachian Basin: Characterization of Central Kentucky Outcrops
David C. Harris, Kentucky Geological Survey, Clay A. Wilcox, Dept. of Geological Sciences, University of Kentucky, and T.M. Parris, Kentucky Geological Survey

Short Courses and Workshops

Special AAPG Short Course on Well Log Analysis

Saturday and Sunday, 17-18 September 2005
Waterfront A&B

Note: Anyone interested in taking this course must register directly with the AAPG Education Department in Tulsa using the form provided!

Who Should Attend: Geologists, engineers, geophysicists and other professionals with a need to understand the responses of common logging measurements to subsurface conditions and become familiar with basic open hole well log interpretation techniques.
About the Course: This course will offer a "hands-on" approach to open hole well log analysis and interpretation while focusing on the traditional interpretation targets of lithology, porosity and fluid saturation. A variety of interpretation techniques will be introduced, including computational to visual (pattern recognition), and the use of some older techniques in the context of the availability of newer, more extensive, data. The course will address logging measurements which are grouped by their interpretation goals, rather than by their measurement physics. The common measurements will be described in sufficient detail for an understanding of their response to subsurface conditions (borehole and formation). Exercises using data from a variety of locations and environments will reinforce the covered interpretation techniques. Both algorithmic and graphical pattern recognition techniques will be covered, as will techniques which use multiple measurements in concert.
Course Content: The course will strive to provide a strong and coherent foundation for the understanding of other, specialized interpretation techniques involving well log data which will not be covered. Topics that will be covered include: an overview of petrophysical well log data acquisition; description of correlation/lithology, porosity and fluid saturation from logs; interpretive techniques using logs individually and in combination; and interpretation exercises to reinforce the interpretation methods discussed.
Duration/Credit Hours: 2 days (AAPG provides 1.5 CEU's.)
Instructor: Daniel A. Krygowski, who currently is with ChevronTexaco in Houston, Texas, was formerly a petrophysicist with Landmark Graphics, where he was involved with petrophysical and user interface development in a number of software products, primarily PetroWorks. He previously held a variety of technical and management positions in petrophysics and software development at ARCO and Cities Service Company. He holds M.S. and Ph.D. degrees in geophysics from the Colorado School of Mines.
Cost: $100, payable directly to AAPG, not with the ES AAPG meeting registration fees. See registration form on page 15.

Note: A limited number of scholarships courtesy of PAPG are available to students. Interested students should send an e-mail to Lee Avary (e-mail: avary@geosrv.wvnet.edu) and indicate university and degree program.
Limit: 32 persons

PTTC Appalachian Region Workshop

Rocks to Models: An Introduction to 3-D Reservoir Characterization and Modeling

Wednesday, September 21
Waterfront A&B

Who Should Attend: Geologists, geophysicists, and engineers involved in reservoir characterization and 3-D geologic modeling.
About the Course: This course provides an overview of 3-D reservoir characterization and modeling concepts and methods. The course addresses different types of petroleum reservoirs (carbonates, sandstones, fractures) and techniques to define or estimate reservoir architecture and reservoir properties within a sequence-stratigraphic and structural framework.
Course Content: Material includes an overview of the objectives for reservoir characterization, analysis of porosity (pore types, porosity classifications) and permeability (matrix, fracture), and common methods used to identify reservoir flow units. We will review stratigraphically- and structurally-compartmentalized reservoirs. We will emphasize the role and significance of outcrop analogs for reservoir characterization and modeling using case studies.

The course covers common methods of constructing 3-D geologic models of petroleum reservoirs. This includes an overview of 3-D geologic modeling techniques, common cell-based (pixel-based) methods, object-based methods, and the use of 3-D seismic data for conditioning reservoir models.
Duration/Credit Hours: 1 day. Certificates of Professional Development Hours (PDH) will be awarded at end of workshop.
Instructors: Matt Pranter (University of Colorado, Boulder Colorado) and Neil Hurley (Colorado School of Mines, Golden, Colorado)
Cost: $75 (Co-sponsored by PTTC)
Limit: 45 persons

NOTE: "Short Course or Workshop Only" is an option for those who can only attend one or both of these activities.

Field Trips

Sequence Stratigraphic Framework of Big Lime reservoirs, West Virginia

September 16, 2005 mid-afternoon –September 18, 2005 noon

Leaders: Thomas C. Wynn, (Lock Haven University), Aus Al-Tawil (Saudi Aramco), and J. Fred Read (Virginia Tech)

This two-day field trip will provide a sequence stratigraphic overview of the Mississippian Big Lime (Greenbrier Group) of West Virginia, a 30 to 500 m (100 to 1600 feet) thick succession of mixed carbonate-siliciclastic sediments that formed on the Appalachian foreland. The trip will examine a south-to-north (basin margin-to-shoreline) transect starting near Lewisburg, West Virginia and finishing at Canaan Valley, West Virginia. The principal theme for the field trip will be the facies, sequence stratigraphy and paleogeography of these oolitic carbonate reservoirs. In the past the Big Lime was lumped into large litho-stratigraphic units that were heterogeneous and difficult to trace regionally. This rock-stratigraphic approach did not allow the facies distribution, stacking patterns, reservoir trends, and effects of tectonics to be clearly elucidated, because there was no obvious way to time-slice the succession.

High resolution sequence analysis throughout the state allowed the interval to be subdivided into fifteen 4th order depositional sequences (20 to 150 ft thick, few hundred thousand year duration) that are traceable throughout the subsurface. This allowed time slice maps to be made that show the complex regional facies trends and geometries, and regional cross-sections to be constructed that define the stacking of facies and reservoirs. The field trip will examine the role played by 4th order eustasy driven by waxing and waning of Gondwanan ice-sheets, coupled with subtle foreland basin tectonics in developing the high frequency sequences It will integrate the outcrop data with the subsurface framework generated using well-cuttings, outcrops, core and wire-line logs from 200 shallow wells throughout West Virginia.

Fee: $110 per person, includes van transportation, guidebook, lunches, and snacks.

Lodging: Participants are responsible for making their own lodging reservations. For Friday night, September 16, call the Super 8 in Lewisburg, WV (304 647-3188) and ask for the Wynn block. For Saturday night, September 16, call the Elkins Motor Lodge (304 636-1400 or 877 636-1863) and ask for the Avary block.

Limit: 20 people.

Pre-registration is required.

Devonian Hydrocarbon Stratigraphy near U.S. Route 250 in Virginia and West Virginia

September 20, 2005-late afternoon –September 22, 2005 mid-afternoon

Trip Coordinator: John M. Dennison

This field trip generally follows U.S Route 250 northwestward from near Churchville, VA across 6 major Devonian outcrop belts from the eastern most outcrop belt to the west flank of the Elkins Valley anticline, where Upper Devonian strata are exposed in a new road cut within 3 miles of wells producing hydrocarbons from the same strata. The guidebook explains the development of Devonian stratigraphic nomenclature along the route from the time of W.B Rogers in 1835 to 1841 to the present. It will include stratigraphic descriptions and interpretations at 11 localities, with multiple stops at some. We will examine the lithology, facies patterns, and sequence stratigraphy of all of the zones which have produced hydrocarbons in the region, some paleontologic evidence on ages and depositional environments, structural geology related to exploration, and also a bit of military geology of several Civil War battles and fortifications en route. Fossil collecting opportunities will be available at several stops. Overnight lodging both nights in Bartow, WV.

Fee: $180 per person, includes van transportation, guidebook, 2 nights lodging (double occupancy), lunches, and snacks.

Limit: 30 people.

Pre-registration is required.

NOTE: "Field Trip Only" is an option for those who can only attend one or both field trips.

ABSTRACTS

Abstracts

Intelligent Seismic Inversion: From Surface Seismic to Well Logs via VSP.

Artun, Emre[1], Mohaghegh, Shahab D.[1], Toro, Jaime[2], Wilson, Tom[2], and Sanchez, Alejandro [3]
[1]Department of Petroleum and Natural Gas Engineering, West Virginia University, Morgantown, WV
[2] Department of Geology and Geography, West Virginia University, Morgantown, WV
[3]Anadarko Petroleum Corporation, Houston, TX

In the petroleum exploration work flow, geologists and geophysicists use seismic data to forecast the possible existence of hydrocarbon resources by structural mapping of the subsurface, and making interpretations of the reservoir's facies distribution. Engineers use this information to make decisions on possible locations for new exploration or development wells. The relatively low resolution of seismic data usually limits its further use. Yet, its areal coverage and availability suggest that it has the potential of providing valuable data for more detailed reservoir characterization studies through the process of seismic inversion.

In this study, a novel intelligent seismic inversion methodology is presented to achieve a desirable correlation between relatively low-frequency seismic signals, and the much higher frequency wireline-log data. Vertical seismic profile (VSP) is used as an intermediate step between the well logs and the surface seismic. A synthetic seismic model is developed by using real data and seismic interpretation. In the example presented here, the model represents the Atoka and Morrow formations, and the overlying Pennsylvanian sequence of the Buffalo Valley Field in New Mexico. Artificial neural networks are used to build two independent correlation models between; 1) Surface seismic and VSP, 2) VSP and well logs. After generating virtual VSP's from the surface seismic, well logs are predicted by using the correlation between VSP and well logs. Density logs were predicted with 87% accuracy through the seismic line. The same procedure can be applied to a complete 3D seismic block to obtain a detailed view of reservoir quality distribution.

Possible Hydrothermal Dolomite Reservoir(s) in the Swan Creek Field, Tennessee

Bailey, Jeffrey R.[1], Evenick, Jonathan C.[2],. Hatcher, Robert D Jr.[2], and Weyland, H. Virginia[3]
[1]Tengasco, Inc., Knoxville, TN
[2]Department of Earth and Planetary Sciences, University of Tennessee, Knoxville, [TN]
[3]U.S. Department of Energy, National Petroleum Technology Office, Tulsa, OK

A possible subsurface hydrothermal dolomite reservoir has recently been identified in the Swan Creek field, northeastern Tennessee. Swan Creek field is in a blind, faulted anticline located beneath the shallow-dipping Clinchport thrust wherein small-displacement duplex imbricates partly localize production. A structural low is superposed on the northwestern flank of an anticline that contains a pronounced increase in dolomite in the lower and middle Stones River (Black River) Group, but hydrocarbon production from surrounding wells is from the top of the Stones River (Carters Limestone). The structural low is evident in maps contoured from top of the Lebanon Limestone downward into the Knox Group, but is not present in younger horizons. Dolomitization probably occurred prior to Alleghanian folding and faulting, but deformation may have localized the hydrothermal zone and hydrocarbons, and did not breach and drain the reservoir. Production probably results from secondary enhanced porosity not cemented by late-stage, pre-Alleghanian fluid migration and mineralization. Trends in hydrothermal fluid migration related dolomite porosity have long been recognized in the zinc districts in Tennessee. For hydrothermal dolomite plays, drilling off structure may be better than drilling on structure. Locating this structure in Swan Creek was as a result of secondary target development, with the Knox Group the original primary target. Oil shows are widespread in Swan Creek in the Stones River and Nashville Groups, but most oil production here is from these dolomites. Wells associated with this hydrothermal event and proximity to their off-structure locations, and disproportionate high cumulative volumes, warrant special economic considerations and investigation.

Oil Field Structural Mapping and the Distribution of Dolomite in the Dundee Formation in Michigan

Barnes, David A., Grammer, G. Michael, Harrison, William B. III, Gillespie, Robb, Stewart, Joshua, Wahr, Amanda, and Kirshner, Joshua
Department of Geosciences, Western Michigan University, Kalamazoo, MI

The Dundee Formation of the Michigan Basin has produced over 350 million barrels of oil since the late 1920's. About half of the 100 fields produce from dolomite, however the origin of dolomite is unclear from the existing literature. A new research project, partly funded by the U.S. Department of Energy, is currently underway at Western Michigan University to determine the origin and distribution of dolomite in the Dundee and two other prolific carbonate reservoirs in Michigan. The objective of the project is to identify mechanisms for dolomite genesis, especially as related to hydrocarbon reservoir geometry and rock properties. Petrographic, isotopic, and fluid inclusion analyses of core and sample material will further refine the interpreted origin of dolomite.

The Dundee in the central Michigan is divided into an upper "Rogers City" and a lower "Reed City" interval. The "Rogers City" is an open shelf wackestone that has minimal primary porosity and permeability. The "Rogers City" has satisfactory reservoir quality only when fractured and pervasively dolomitized. The "Reed City"

contains significant primary porosity and permeability in shallow shelf skeletal grainstones and boundstones. “Reed City” reservoirs are mostly present in limestone parts of the formation although important reservoir intervals also exist in dolomitized areas.

Application of digital structural mapping techniques and lithologic analyses of digital wireline log data provides insight into the origin of the dolomite. Lateral and stratigraphic extent of dolomite in many central basin Dundee fields is closely related to oil field scale structures interpreted as faulted, asymmetrical anticlines and/or high density, small-scale faults lower on structures. Direct spatial correlation between intensity of dolomitization and these interpreted fault features supports a fracture-related, probable hydrothermal component to dolomitization in many, central Michigan basin Dundee fields.

The Upper Devonian Dunkirk Shale – A Late Hydrocarbon Generator

Blood, David R.[1],and Lash, Gary G.[2],
[1]Dept. of Geology, University at Buffalo, Buffalo, NY
[2]Dept. of Geosciences, SUNY-Fredonia, Fredonia, NY

Hydrous pyrolysis experiments were carried out on the basal Upper Devonian Dunkirk black shale of western New York State to assess its hydrocarbon generative potential. The Dunkirk shale at the sample locality is immature to early mature (R_o=0.53%) and composed predominantly of Type II and lesser Type III organic kerogen. Black shale samples were run for 72 hrs at temperatures ranging from 305 °C to 357 °C; each sample was analyzed for TOC and Rock-Eval parameters. Samples pyrolyzed from 305 °C to 344 °C showed a modest increase in production index (PI) from 0.11 to 0.22 and, perhaps more significantly, only a minimal increase in Rock-Eval T_{max} from 443 °C to 446 °C. However, the increase in temperature from 344 °C to 357 °C was accompanied by increases in PI to 0.61 and T_{max} to 582 °C. Similarly, hydrogen index (HI) over the 305-344 °C range diminishes from 356 to 216; however, from 344 to 357 °C, HI drops to 11. It appears, then, that organic matter of the Dunkirk shale resists conversion until a threshold level of thermal maturity is reached when the kerogen rapidly decomposes to liquid hydrocarbons. The refractory nature of Dunkirk shale kerogen is confirmed by bulk kinetics analyses of three Dunkirk shale samples of variable R_o (0.53-0.73%) that reveal that the bulk (>80%) of the conversion reactions require activation energies in the range of 5,400-5,500 cal/mole, values that are typical of documented late-oil generators, including the Woodford shale. Further, 10% and peak hydrocarbon generation of the Dunkirk shale would occur at R_o=0.88-0.92% and 1.08-1.14%, respectively.

Sedimentary and Transcurrent Fault Control on Dolomitized Grainstone Reservoirs in the Upper Ordovician Black River and Trenton Limestone Groups in Ontario, a Comparison with Northern Afghanistan

Brookfield, Michael E.
Land Resource Science, Guelph University, Guelph, Ontario, Canada

Dolomitized bioclastic grainstones form the main hydrocarbon reservoirs in the Ordovician of Ontario. These are controlled both by depositional environment and by tectonics. Environmental position on the ramp determined where the contributing organisms lived and how they were reworked. Tectonics not only determined the configuration of the ramp and where Precambrian inliers occurred (which themselves locally control grainstone location), but also movements on faults which controlled the dolomitization.

By analogy with carbonate ramp models based on modern environments (the most applicable one being a cool Persian Gulf ramp), bioclastic grainstones occur in two main settings: in shallow shelf shoal areas around normal wave base, and in deeper shelf areas affected by contour currents. The grainstones form the tops of coarsening (and possibly shallowing) upwards cycles within a generally transgressive succession

By analogy with tectonic models based on Cenozoic collisions (the most applicable one based on the indentation and rotation of Afghanistan by NW India), Ordovician dolomitization and reservoir formation occurred along lateral transtensional and transpressional faults related to collision of the Taconic arc with the Ordovician carbonate ramp. Differential shear can be related to the contrast between the Taconic arc indenter and the areas to the north - the dividing line roughly running from Anticosti Island down the St Lawrence into southern Ontario.

The Ordovician succession in Ontario and New York is now known to be at least partially controlled by synsedimentary tectonics. Such successions, especially in the absence of a reliable chronostratigraphy, should not automatically be assumed to consist of blankets of uniform and easily correlated facies controlled by relative changes of sea-level.

Increasing the Value of 2-D Seismic Data through Application to Development Drilling

Carney, B.J.
Columbia Natural Resources, LLC., Charleston, WV

There have been vast quantities of 2-D seismic shot in West Virginia to image various exploration targets in the Oriskany, Trenton/Black River, Newburg, and Tuscarora, just to name a few. However, once these targets are sufficiently tested in a prospect area, the seismic data is often shelved. That same old 2-D data can provide great value in maximizing your reserves in your Devonian shale drilling program.

Various seismic characteristics can be used to identify prospective areas for enhanced recovery from Mississippian and

Devonian formations. Early Cambrian Rome Trough fault reactivation is shown to be an adequate predictor of improved fracturing, and thus, production in these shallow zones.

Estimated Ultimate Recovery (EUR) values for a group of wells were loaded into a database from which reserve "bubble" maps were constructed for a portion of southern West Virginia. A 2-D seismic database was then used to map various attributes relating to well production including basement fault trends, Onondaga fault trends, Onondaga structure, Berea structure, Big Lime structure, Berea to Onondaga Isochron and Isopach maps. Reserves were then compared to mapped seismic features.

A strong correlation between reserves and proximity to deep-seated faulting is evident. Two ideas for this correlation are proposed for this result, with the likelihood that a mixture of the two is occurring in the high-volume producers. Reactivation of deep faults could have created a buttress effect in the underlying Siluro-Devonian section, creating a mechanism for shallow thrusting in the Devonian shale. Secondly, the reactivation of deep faults could have propagated into the shales, where it dissipated into a series of smaller fractures.

A Multi-Disciplinary Approach for Mapping Rock Units with Geologic Carbon Sequestration Potential

Carter, Kristin M.[1], and Venteris, Erik R.[2]
[1]Pennsylvania Department of Conservation and Natural Resources, Bureau of Topographic & Geologic Survey, Pittsburgh, PA
[2]Ohio Division of Geologic Survey, Columbus, OH

Members of the Midwest Regional Carbon Sequestration Partnership have collaborated to map the structure and thickness of several discreet geologic packages that may have potential for carbon dioxide sequestration. This research is being conducted as part of the U.S. Department of Energy's national network of Regional Carbon Sequestration Partnerships. A unique, multi-disciplinary approach was adopted that included compiling a wide range of legacy data and mapping it using a combination of computer and hand contouring. Comprehensive databases of the seven-state study area were built from members' digital oil and gas well databases, as well as core, outcrop, subcrop, and seismic data. Existing geologic maps and cross sections were used during map preparation where digital data gaps and/or complex structural relationships were encountered. Structure and isopach contour maps were generated using computer contouring (Geostatistical Analyst (ArcGIS) and PETRA), with varying degrees of manual contour manipulation. Conversion of contour lines to vectorized grids (for evaluation of carbon sequestration potential) proved challenging due to complex geologic structures such as the Rome Trough and occasional large data gaps. Several methods for conversion of hand-edited contour maps to grids were evaluated. Structure contour maps of selected study units, ranging from Cambrian to Lower Devonian in age, are presented as examples of the multi-disciplinary approach employed by the Partnership.

Petrophysics of Medina and Tuscarora Sandstones and Integration with the Tectonic-Stratigraphic Framework, Appalachian Basin, U.S.A.

Castle, James W.[1], and Byrnes, Alan P.[2]
[1]Clemson University, Department of Geological Sciences, Clemson, SC
[2]Kansas Geological Survey, Lawrence, KS

Petrophysical properties were determined for six facies in Medina and Tuscarora sandstones of the Appalachian basin: fluvial, estuarine, upper shoreface, lower shoreface, tidal channel, and tidal flat. Fluvial sandstones have the highest permeability for a given porosity and exhibit a wide range of porosity (2-18%) and permeability (0.002-450 mD). With a transition-zone thickness of only 3-20 feet, fluvial sandstones with permeability greater than 5 mD have irreducible water saturation (S_{iw}) less than 20%. Upper shoreface sandstones exhibit good reservoir properties with high porosity (10-21%), high permeability (3-250 mD), and low S_{iw} (<20%). The other sandstone facies have lower porosity, lower permeability, thicker transition zones, and higher S_{iw}.

The most favorable reservoir petrophysical properties and the best estimated production from the Lower Silurian sandstones are associated with fluvial and upper shoreface facies of incised-valley fills, which we interpret to have formed predominantly in areas of structural recesses that evolved from promontories along the collisional margin associated with the Taconic orogeny. Although the total thickness of sandstone may not be as great in these areas, reservoir quality is better than in adjacent structural salients, which is attributed to higher energy depositional processes and shallower maximum burial depth in the recesses than in the salients.

Oil and Gas Development in the Urban Environment of Los Angeles

Clarke, Don
Geological Consultant, Lakewood, CA

The history of Los Angeles is closely tied to the history of petroleum. Edward Doheny and Charlie Canfield discovered the Los Angeles City oil field in 1892. With that discovery came revolutionary change. Doheny sold the idea of replacing expensive coal ($20 per ton) with cheap oil at ten cents per barrel. With 3.6 barrels of oil having the same heating capacity as one ton of coal, oil was a bargain. Cheap energy along with water that was being brought in by the Metropolitan Water District combined with the Mediterranean climate to make southern California a paradise. The

Washington navel orange became the nationally recognized cash crop. Transportation and other industries followed and prospered. Oil operations continued to expand as the city grew over early oil development. This talk will look at the history of petroleum production with an eye to how that history has impacted the petroleum production elsewhere. Many of the solutions to problems found here have been and will be applied elsewhere as urban development swallows up petroleum producing areas. With 14 million people living and working over billions of barrels of oil that are on production Los Angeles will continue to be a place where solutions are found.

The Influence of Cryptic Lineaments upon Patterns of Iron Mineralization, Appalachian Plateau, Western Pennsylvania

Coyle, Paul R.[1], and Anderson, Thomas H.[2]
[1]Coyle Geological Services, Pittsburgh, PA
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In the Allegheny Plateau of west central Pennsylvania siliceous iron rich Buhrstone composes a thin irregular layer 1 to 50 cm thick at the top of the Pennsylvanian marine Vanport Limestone. The Buhrstone horizon that may include iron-oxide, siderite, clay or a combination of these, is restricted to the Vanport. However, the mineralized layer is not everywhere present, as shown by outcrops and 970 drill-holes throughout an area of 4700 km^2. Overlying strata consists, principally of shale and channels that locally cut through the Vanport and are filled with sandstone. Common Fe-stained strata, mineralized fossils and iron-filled fractures in and above the Vanport, indicate that the ore was precipitated. The occurrences of ore distinguish some elongate bodies that trend northwest and are parallel to a panel within which the channels are most extensively developed. The ore bodies, with the associated clay and siderite, and the sandstone channels delineate zones about 24 km wide. We interpret the margins of this zone to coincide with cryptic cross-strike discontinuities (CSD's) with little or no surface expression. Furthermore, changes in the generally northeasterly trend of folds, saddles located on anticlines and structural depressions in the Vanport Limestone occur at the intersection with the cryptic lineaments. The geological features recorded by the Vanport suggest that structural discontinuities control the distribution of the ore. Fluid flow-paths, parallel to lineaments striking N60^{o}W, are also influenced by the cryptic structures.

Volume Fraction Analysis of Two-Phase Flows in Fractures

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Rock fractures have been known to provide primary flow paths for subterranean fluid flows. The interaction between CO_2 and liquid saturated reservoirs is an interesting area of research. This work attempts to provide an understanding of the processes involved and also to derive an empirical equation relating the pressure drop for multi-phase flow through fractures. Here the volume of fluid multi-phase model of FLUENT code is used to describe the flow.

The issues posed by carbon-dioxide sequestration are similar in nature to the study of reservoir flooding, especially when carbon-dioxide sequestration is used for enhanced resource recovery. This work presents a computational analysis of the percentage of in-place oil that is removed by an injected fluid through an idealized set of fractures with varying properties. Different aperture heights are compared against each other in an effort to quantify the effect that abrupt changes in height have on the flow properties. This is representative of the abrupt height changes seen in natural fractures, highly simplified in order to isolate the specific aspect of current interest.

Work thus far has shown that the velocity of the invading fluid has the most dramatic effect on removal efficiency, with flows above the creeping regime removing a smaller percentage of in-place oil. Varying aperture height is shown to affect the removal efficiency as well, with the most restrictive passages hindering the flow and creating areas of trapped in-place oil along the flow path.

Geologic Cross Section through the Appalachian Basin from Sandusky County, Ohio, to Hardy County, West Virginia

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A new geologic cross section through the central Appalachian basin provides a regional structural and stratigraphic context to better understand petroleum systems, coal systems, and basinwide fluid-flow models. The cross section is constrained by 13 drill holes, 4 of which penetrate the Paleozoic cover rocks of the basin and bottom in Grenville-age crystalline basement rocks, and by regional structure contour maps. Sedimentary rocks shown on the cross section span most of the Paleozoic Era, and their preserved thicknesses range from about 3,000 ft on the Findlay arch to about 27,000 ft in the Rome Trough near the Chestnut Ridge anticline extension. These rocks are broadly classified as follows: (1) Lower Cambrian to Upper Ordovician siliciclastic and carbonate strata (rift and passive margin deposits); (2) Upper Ordovician to Lower Silurian siliciclastic strata (Taconic orogeny foreland basin deposits); (3) Lower Silurian to Middle Devonian carbonate and evaporite strata (shallow marine deposits); (4) Middle Devonian to Lower Mississippian siliciclastic strata (Acadian orogeny foreland basin deposits); (5) Upper Mississippian carbonate strata (shallow marine deposits); and (6) Upper Mississippian, Pennsylvanian, and Permian siliciclastic strata (Alleghanian orogeny foreland basin deposits). Styles of deformation illustrated are: (1) thin-skinned contractional structures of Alleghanian origin at the Allegheny structural front (Wills Mountain anticline) and in the adjoining foreland (Blackwater, Deer Park/Leadmine, and Etam anticlines) and (2) basement-involved Middle Cambrian extensional faults that flank the Rome trough. At several localities, deeply rooted anticlines that involve basement rocks appear to have been caused by fault-block reactivation during the Alleghanian orogeny.

A Basin-wide Geologic Resource Assessment of the Upper Devonian Interval in the Appalachian Basin

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The Upper Devonian interval (Venango, Bradford, and Elk Groups) is one of the most prolific natural gas-producing intervals in the Appalachian basin. Data from the most recent 5 year reporting period indicate that the Upper Devonian interval accounted for over 90% of the reported production in Pennsylvania and nearly half of all completions in West Virginia. Despite these statistics, recent natural gas assessments of the interval are lacking.

The last detailed basin-wide investigation of the Upper Devonian's resource potential, conducted in 1992 by the Department of Energy (DOE), was not widely released. Since that time, more data points have become available through the release of proprietary data and from recently drilled wells. However, limited oil and gas industry resources and concerns over sharing confidential information between competing companies has limited efforts for a basin-wide resource assessment of the Upper Devonian. The DOE's National Energy Technology Laboratory (NETL) has recently initiated an effort that builds on the work from 1992 and integrates new data from industry and public sources to assess the remaining potential of this interval.

This study aims to produce a better understanding of the geologic complexities and the size and nature of the remaining natural gas resource of this interval. Work will include production of detailed, basin-wide geologic cross-sections and maps delineating sandstones of the Upper Devonian interval, followed by a characterization of the remaining natural gas resource in terms of gas-in-place and technically recoverable resource. Results will be made publicly available on a CD report from NETL.

Potential Carbon Sequestration Targets in Saline Reservoirs of Kentucky

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If a carbon-constrained future requires reduced CO_2 emissions, one of the first areas to be affected likely would be the coal-fired power industry. Because of the large volumes of CO_2 produced by Kentucky power plants, sequestration in geologic formations would be an important strategy for meeting air-quality compliance guidelines.

Based on current knowledge, the geologic sequestration option in Kentucky that shows the greatest likelihood for sufficient capacity, safety, and permanency is the deep saline reservoirs. To be effective, these reservoirs would have to be deeper than about 2,500 feet to assure sequestration of supercritical CO_2 and would have to have sufficient injectivity and volume to accept several million tonnes of CO_2 annually from each plant over lifetimes of 30 to 40 years.

Based on reservoir thicknesses and areal extent, some of the best locations for potential sequestration sites in Kentucky would be along the Ohio River between Cincinnati, Ohio, and Union County, Ky. In this area, possible sequestration targets include sandstones in the Mount Simon, St. Peter, and Rose Run Formations and vuggy dolostones in the Copper Ridge Formation. Other areas in Garrard, Madison, and Clark Counties, as well as parts of Elliott and Lawrence Counties, Ky., have deep Rome sandstones that are possible sequestration targets. A porous sandstone in the Middle Run Formation of Hart and Hardin Counties is also a potential sequestration site.

Prior to any large-scale CO_2 injection into these potential target formations, reservoir mineralogy, integrity, heterogeneity, permeability, and structural closure would have to be assessed.

Sequestration Potential in the Illinois Basin Coal Beds

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Maps of extent, thickness, depth, and elevation have been created for seven major coal beds in the Illinois Basin, including: Danville, Hymera/Jamestown/Paradise, Herrin, Springfield, Survant, Colchester, and Seelyville/Davis/Dekoven. Additional maps (e.g. temperature, pressure, heating value) were also generated to assess the phase of the CO_2 being sequestered. The temperature range of 65 to 85 ^{o}F and pressure range 225 to 600 psi in the coal beds indicate a gaseous phase for the potentially sequesterable CO_2.

Coal thicknesses, areal extents, as well as other mapped and measured parameters were used to estimate: a) *in situ* adsorbed coal-bed methane content, b) amount of CO_2 that can be adsorbed onto the coal matrix, c) free phase CO_2 that can reside in the cleats, and d) CO_2 that can be dissolved in formation water. Where the areal distribution of coal quality data was sparse, high, medium, and low probabilistic values were selected from the distribution of measured values to put key variables into the equations, encompassing the range of uncertainty associated with these data. The volumetric equations were incorporated into a cellular GIS model for each coal bed map layer, and the results were summed to obtain the basin-wide estimates of CO_2 sequestration. Our preliminary volumetric calculations suggest that the combined volume available in the coal beds within the basin is 3.5 billion metric tones of CO_2. These values are preliminary estimates only, since numerous parameters that are important for CO_2 adsorption (for example, maceral composition, cleats distribution and pore characteristics) are poorly documented. Moreover, the gaseous state of CO_2 within this low pressure/temperature range occurring in the coal beds of the Illinois Basin raises concerns about the feasibility of CO_2 storage in these relatively shallow coals. These concerns include: stability and effectiveness of CO_2 adsorption, reactivity of CO_2 with macerals and other surrounding mineral phases, and possibility of gas leakage and migration.

Shoaling Upward Cycles (Parasequences) and their Significance in the Black River -Trenton Carbonates (Ordovician)of Southern Ontario, Canada

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The Black River and Trenton Groups form a thin (average 150 metres) transgressive systems tract of a Middle to Upper Ordovician carbonate depositional sequence. Within this tract, various upward shoaling cycles bounded by flooding surfaces (parasequences) can be used for local correlation.

The Black River contains symmetrical and asymmetrical low energy 'lagoonal' - supratidal cycles within a generally deepening (backstepping) succession. Flooding surfaces are marked by various condensed 'glauconitic' horizons with a marine, though somewhat low-diversity, fauna. The facies can be directly compared with those of the modern Persian Gulf. The Black River- Trenton boundary is a major flooding surface separating a 'lagoonal'-tidal flat succession (Black River) from an open marine succession (Trenton Group). This change is practically synchronous from Lake Simcoe to Kingston and marks either a relatively rapid and significant rise in relative sea-level, or an erosion surface caused by shelf reworking between depositional shoreline and deep shelf facies. Interpretations of this open shelf succession are difficult due to major biological changes since the Ordovician; though the 'shaved shelf' depositional model of James et al.(1994) may be more appropriate than current conventional models..

The Trenton Group also contains asymmetrical and symmetrical cycles (like the Jurassic Klupfel cycles of western Europe), whose resistant capping grainstones form persistent and mappable units over much of southern Ontario. Like Klupfel cycles, the Trenton cycles become more symmetrical and complete from shelf to basin (from western Ontario to central New York). Furthermore, each cycle contains distinctive biofacies and nektonic/pelagic faunas related to extinction and recolonization.

The Effects of CO_2 Interaction with Coal

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An important option for long-term storage of carbon dioxide (CO_2), a greenhouse gas, is to capture it from power plant flue gas and sequester it in coal seams. Here, we report the nature and relative significance of CO_2 interactions with coal, based on attenuated total reflectance-Fourier transform infrared (ATR-FTIR) spectroscopy. Experiments were carried out at temperatures ranging from 328 K to 383 K (55 ºC to 110 ºC) and CO_2 pressures ranging from 0.35 MPa to 14 MPa. Data was obtained by observing the sorbed CO_2 band on Argonne Premium coal samples around 2330 cm^{-1}. Kinetic studies reveal that with repeated exposures, subsequent CO_2-coal sorption is much faster than the initial uptake and the amount of CO_2 sorbed increases, indicating that exposure of coals to CO_2 under these conditions results in changes in the physical structure of the coal. The energy of adsorption for the Argonne Premium coal samples was estimated to be ~20-25 kJ/mol, using the Van't Hoff equation. These values are consistent with physisorption and compare well with the literature values reported. In addition to kinetic studies, high pressure CO_2 adsorption isotherms have been measured using ATR-FTIR. Adsorption isotherms are important to measure the CO_2 storage capacity in coal seams.

Creating an integrated coal geology and coal mining Geographic Information System in West Virginia.

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In 1995, the West Virginia Geological and Economic Survey (WVGES) was directed to create a Geographic Information System (GIS)-based inventory of the coal resources in West Virginia. Since then geologists have been creating a series of resource maps for each bed including structural contour and outcrop lines; net coal, total bed height, and percent partings isopach maps; depth-of-overburden; mined areas (by mining method); bed discontinuities; thickness and elevation control points; coal quality variation; and others. The effort is supported by numerous databases including ones dedicated to stratigraphic data, coal quality data, and underground mine map documents. An integrated system continues to evolve centered around the GIS software platform connected to robust Relational Database Management software through Spatial Database Engine.

Up-to-date mapping and information about coal geology and coal mining in the state in a flexible GIS format is in demand for issues such as future economic impact of coal, mine safety, development of all kinds, assessment of environmental impact of mining, assessment and remediation of abandoned mine land problems, fair and equitable taxation, and many others. Geographic Information System (GIS) technology provides tools not only for creation and efficient storage of coal geology and resource maps, but also provides means to readily manipulate the information for specialized and focused analyses.

Assessing Carbon Sequestration Potential for "Unmineable" Coal Beds in Eastern Kentucky

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Coal beds are possibly attractive sequestration reservoirs because they adsorb CO_2 and because injected CO_2 will displace in-place methane, which can be recovered as a fuel. If used for sequestration, however, the injected coal cannot be mined in the future. For carbon sequestration and coalbed methane development, it is important to identify coals that are unmineable, below drainage, and below the level of surface fractures (500 feet). Defining "unmineable" is problematic. Options include thickness or depth restrictions based on current mining technology, stratigraphic limits based on seams that are not currently mined, or areas that exclude current mining. In eastern Kentucky, the latter two would eliminate much of the coal field, because active mining is where coals are thickest. In order to demonstrate the effects of the economic and political factors that might determine which coals were truly unmineable, a second calculation was made for coals more than 1000 feet below drainage.

At 500 feet below drainage, the areas with sequestration potential are in the Eastern Kentucky Syncline and Middlesboro Syncline, in all or parts of 15 counties, with a maximum of 15 potential seams in a small part of that area. At 1000 feet, the area shrinks to 6 counties, most with less than 2 potential seams and a maximum of 8 potential seams in the deepest parts of these structures. There are no current power plants in this area, which means that its coal sequestration potential would depend on the economics of pipelines and methane recovery.

Siting Coal-Fired Power Plants in a Carbon-Managed Future: the Importance of Geologic Sequestration Reservoirs

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In a carbon-managed future, coal gasification technology will be used to produce electric power and hydrogen from coal with near-zero emissions. CO_2 will likely be captured and sequestered in the subsurface. This is important, because existing power plants are not sited based on the potential reservoir space near the plant. If the economics of reducing carbon emissions require sequestration in the future, then existing siting factors will have to be coupled with geologic criteria to determine optimal plant locations. To illustrate future potential in Kentucky, the locations of existing power plants, suitable water sources, and seismic risk were combined to delineate an energy and power infrastructure area. Within this area, potential geologic reservoirs were defined. In Kentucky, depleted oil and gas reservoirs and deep saline aquifers (permeable sandstones and carbonates) are sequestration possibilities where they occur at depths in excess of 2,500 feet. Because of their adsorptive properties, coals and organic shales are options at shallower depths, but still need to be both below drainage, and the level of surface fracturing. In all cases, potential reservoirs must have an adequate seal to prevent leakage of sequestered CO_2, and capacity and injectivity volumes of at least 1 million tons of CO_2/year for 30 years, a standard set for a FutureGen gasification plant. These limitations result in variable potential across the energy and infrastructure area. More information about reservoir permeability, heterogeneity, structural closure, water chemistry, mineralogy, and other geologic factors are needed to better calculate injectivity and actual storage volumes.

Improved Understanding of Regional Geologic CO_2 Storage Options through Collaboration with Oil and Gas Industry

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A "piggyback" exploration approach has been developed by Battelle to improve the geological understanding of deep sedimentary reservoirs that are candidates for CO_2 storage in the Ohio River Valley Region. The approach hinges upon a mutually beneficial collaboration with oil industry for planned or ongoing exploration in the region to conduct additional drilling, rock coring, wireline logging, and analysis of seismic data to better characterize sedimentary zones that are generally not evaluated during typical exploratory drilling. In addition to characterizing the extent and storage parameters for regional sandstones such as the Mt. Simon Sandstone and the Rose Run Sandstone, there is an emphasis on locating and characterizing the zones of primary or secondary permeability in the thick carbonate sequences present in the deeper basin areas. Even laterally small zones of karst or secondary permeability in these carbonates can provide extremely large storage capacity and injectivity. Two Rose Run/Copper Ridge wells and one Devonian Shale well in southeastern Ohio have been investigated. Results from these wells were combined with the detailed information obtained from the AEP #1 well at Mountaineer Plant in West Virginia. These three wells provide correlation of geology along the general strike in the study area and demonstrate the extent of regional continuity in the Rose Run Sandstone and a section of the Copper Ridge formation with very high permeability. Future plans for the project include expanded effort in areas where there is a lack of information on deep storage reservoirs. Ultimately the comprehensive assessment of the compiled data along with knowledge of the sedimentary history of the area can be used to develop models for depositional environments and improve predictability of sequestration targets in this region. The results of these studies will help reduce the cost of CO_2 storage by minimizing the pipeline requirements, help locate new reservoirs, increase public confidence in storage capacity, help develop monitoring and verification technologies specific to the geologic setting, and help verify the storage potential in various target formations by validating current theoretical estimates with actual field geologic data.

Analogs for Fault-Controlled Ordovician Dolomite Reservoirs, Appalachian Basin: Characterization of Central Kentucky Outcrops

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Dolomitized Ordovician carbonates outcropping on the eastern flank of the Cincinnati Arch in central Kentucky are analogs for Trenton/Black River gas reservoirs in the northern Appalachian Basin. The dolomite bodies occur adjacent to faults in the Lexington (Trenton) and Calloway Creek Limestones within the Central Kentucky Mineral District. These shallow dolomites are being characterized with conventional and cathodoluminescent petrography, trace element and stable isotope geochemistry, high-resolution seismic-reflection imaging, and fluid inclusion analyses.

Petrography documented two dolomitization events and several phases of calcite cementation. Early dolomite is fine grained, euhedral, with luminescent zoning defined by variation in Fe and Mn trace element concentration. This dolomite replaced calcite matrix and some skeletal grains. Early dolomite is characterized by average δO^{18} values of -3.8 ‰ PDB. Later saddle dolomite occurs in vugs and skeletal molds, and replaces grains, and is moderately to strongly ferroan and non-luminescent. δO^{18} values for saddle dolomite average -7.3 ‰ PDB. The trend toward lighter oxygen isotope values might be due to increasing temperature during dolomitization with late-stage dolomite being precipitated at temperatures higher than expected based on burial history.

Analysis of a 1,005-ft continuous core through the largest outcropping dolomite body indicates that dolomitization decreases with depth. Distribution of dolomite is not directly related to proximity to the boundary fault or depositional facies. Additional geochemical and fluid inclusion data being obtained from this core will allow development of a refined dolomitization model for Ordovician carbonates in central Kentucky, and can be applied to exploration deeper in the basin.

CO_2 Sequestration-Assisted Enhanced Hydrocarbon Recovery Potential In The Midwest Regional Carbon Sequestration Partnership

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The Midwest Regional Carbon Sequestration Partnership (MRCSP) has recently completed extensive GIS-based mapping of potential carbon dioxide (CO_2) sequestration reservoirs, including oil and gas fields, for seven states in the Midwest and Eastern U.S. Cumulative oil production for the seven-state partnership exceeds 5.5 billion barrels. Relatively few of these oil reservoirs have undergone enhanced oil recovery operations.

CO_2-assisted enhanced recovery is ongoing in many U.S. states and currently produces millions of barrels of oil per day. In addition to the enhanced oil production, these projects can sequester significant volumes of CO_2. Total oil recovery using CO_2 varies with reservoir properties, but often ranges between 20 and 30% of the primary recovery volume. For the MRCSP region, CO_2 enhanced oil recovery could produce hundreds of millions of barrels of additional oil and sequester over 2 billion tons of CO_2

Currently, very few CO_2-assisted enhanced recovery projects exist within the MRCSP Region. One dramatic example, however, is the development of CO_2 enhanced recovery of oil in some Niagaran (Silurian) pinnacle reefs of northern lower Michigan. Two reefs were converted to CO_2 enhanced recovery flooding in 1996 and have produced over 600,000 barrels of oil and sequestered over 280,000 tons of CO_2 to date.

Significant additional potential for CO_2 sequestration and natural gas recovery exists in coal seams and organic shales through the MRCSP region. CONSOL Energy is engaged in a project to research the production of methane and injection of CO_2 in overlying coal seams in Marshall County, West Virginia.

Pre–Chattanooga (Devonian-Mississippian Black Shale) Structure and Nashville (Trenton)-Stones River (Black River) Hydrocarbon Production in Tennessee, Kentucky, and Southwestern Virginia

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The Nashville (Trenton) and Stones (Black) River Groups comprise one of the major petroleum systems in the Appalachian basin, and have been productive for decades. Reservoirs in Tennessee, Kentucky, and southwestern Virginia are in limestones of variable porosity (both primary and secondary), with oil production most commonly from the lower and upper Stones River Group (Murfreesboro and Lebanon) and middle Nashville Group (Bigby-Cannon). A disconformity with variable amounts of erosion separates the two groups. Some areas that should be productive are not, while others for which geologic data exist that should not be productive turn out to be productive. An additional variable is compressional structures that formed prior to formation of the pre-Chattanooga (Devonian-Mississippian black shale) unconformity. These structures consist of folds and faults truncated by the unconformity, and are most easily documented on the surface. Numerous examples are published in Tennessee Division of Geology quadrangle geologic maps, and we have also mapped them in the subsurface beneath the eastern Highland Rim and Cumberland Plateau where adequate well control exists. These structures were tilted by subsequent uplift on the Nashville dome and Cincinnati arch, superposing a southeast regional dip that in some cases may cause spilling of potential traps, in others increasing the opportunities for survival of hydrocarbons. These structures should be considered as possible additional structural traps throughout the Appalachian basin.

Treating Natural Gas Storage Produced Waters Using Constructed Wetland Treatment Systems

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Natural gas storage produced waters vary widely in chemical constituents and concentrations. An economically viable approach is needed to treat these waters for either discharge or reuse. Specifically designed, modular pilot-scale constructed wetland treatment systems were built to treat natural gas storage produced waters with salt concentrations ranging from nearly fresh to hyper saline. Both organic and inorganic constituents were targeted for treatment in these systems. The performance of these pilot-scale constructed wetland treatment systems was measured against National Pollution Discharge Elimination System permit limits. The modular approach allowed flexibility to deal with the wide ranging concentrations of organics and inorganics (salts and metals) found in the various natural gas storage produced waters. Pilot-scale systems provide data regarding the feasibility of this approach for treating gas storage produced waters of various compositions. Constructed wetland treatment systems are reliable, flexible in design, and can be built, operated, and maintained at lower costs compared to the current treatment methods of reinjection and chemical treatment. Robust constructed wetland treatment systems designed to treat organics and inorganics are a viable approach for treating natural gas storage produced waters from a variety of gas storage fields.

Using Normalized Residual Polarization (NRP) Analysis of Ground Penetrating Radar Data to Detect Jet Propellant in Soils

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The success of using amplitude variation with offset (AVO) analysis of seismic reflection data for locating petroleum resources has prompted researchers to examine this application for delineating contamination in the near surface. The analogies of elastic (seismic) to electromagnetic (EM) wave propagation and energy partitioning at interfaces has prompted interest in pursuing AVO analysis methods for delineating near surface targets with ground penetrating radar (GPR). This research was initiated to determine the applicability of AVO/GPR techniques for delineation of jet propellant-4 (JP-4) and jet propellant-5 (JP-5), which are both a light non-aqueous phase liquid (LNAPL). This paper presents the results from a case study where the normalized residual polarization (NRP) method was developed for analyzing AVO/GPR data.

Ground penetrating radar data were collected at a former fuel farm (FFF) where a JP-4 and JP-5 release occurred. The FFF site is located at the United States Coast Guard (USCG) Support Center facility located in Elizabeth City, North Carolina. The near surface geology of the FFF consists of clayey silt with varying amounts of clay and interspersed sand lenses overlying fairly uniform fine-grained sand.

Results of the NRP AVO analysis of the GPR data indicate that identifiable anomalous responses are associated with zones of free phase LNAPL in the soils. Furthermore, it appears that the characteristics of the anomalous responses may allow the user to determine if the anomalous response is due to NAPL or due to other subsurface features such as stratigraphic changes.

Recent Appalachian Basin Mergers and Acquisitions

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A presentation has been prepared of recent Appalachian Basin acquisitions to provide operators better insight into the historic basis for asset sales. The materials presented are drawn from public data sources, press releases, and Securities and Exchange Commission Reports.

The presentation includes a discussion on "Price Drivers" - factors that influence a purchase or sale price and "Pricing Yardsticks" – common methods for determining an asset's worth including quick look "Rule of Thumb" methods and reserve based methods. The presentation compares the historic impact of the prime interest rate and natural gas prices on oil and gas asset acquisition values. Historic average Appalachian Basin asset values are presented for the years 2000 – 2004 in $ per Mcfe of proved reserves and in $ per MMcfdeq.

Details of acquisitions are presented including the asset size ($), annual cash flow, daily production, net proved reserves, geographic location, well count, miles of pipeline, and acreage.

Acquisition details are presented for EOG acquiring Energy Search, Inc., Triana Energy Holdings acquiring Columbia, EXCO Resources acquiring North Coast Energy, Range Resources acquiring First Energy's 50% of Great Lakes Energy Partners, Capital C Energy acquiring Belden & Blake, and Fortuna acquiring Belden and Blake's Trenton Black River acreage and wells. Finally, a comparison is made of the "Price Drivers and Pricing Yardsticks" for each of the acquisitions presented.

Gas Capillary Sealing as a Mechanism of Seal Development in the Upper Devonian Dunkirk Shale, Western New York State

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The Upper Devonian Dunkirk black shale, western New York State, was top seal to fluids migrating upward from deeper in the sediment pile. The high sealing capacity of the organic-rich shale reflects a number of factors, including a strongly oriented platy grain microfabric, abundant organic matter, and an anoxic depositional environment. However, the Dunkirk shale is not an especially thick seal by modern standards. The duration of a seal before capillary failure is proportional to the square of the seal thickness and inversely proportional to the permeability of the seal. Assuming that the Dunkirk shale had been compacted to its present 17 m thickness by the time it halted vertically migrating fluids and using a mean permeability of 2.6×10^{-21} m^2 for the Dunkirk shale based on porosimetry measurements indicates that the black shale seal would have been compromised after only 270 years. Indeed, confinement of overpressured fluids by the Dunkirk shale for 1 MY would have required a permeability less two orders of magnitude lower than the lowest measured permeabilities. The extraordinarily high sealing capacity of the Dunkirk shale may reflect the formation of a gas capillary seal, an especially durable barrier that can form in layered sequences of variable grain size and in the presence of free methane. Moderately depleted carbon isotope values of carbonate samples collected from Dunkirk shale concretions probably reflect the generation of biogenic methane in these deposits. Interlaminated siltstone and claystone in the lower Dunkirk shale provided the framework within which to segregate biogenic methane and water.

Site Selection for Carbon Sequestration in Saline Reservoirs

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Deep saline reservoirs represent the largest component in the portfolio of geologic storage capacity for sequestered CO_2; therefore, adequate evaluation of these reservoirs is of paramount importance. An evaluation of a potential sequestration site commonly includes: regional analysis of porosity and permeability, analysis of the reservoir seal, subsurface structure mapping of the target reservoir, identification of transmissive faults that might leak CO_2, evaluation of the lateral continuity of the reservoir, and delineating the limits of potable water. During site selection it is important to evaluate the effects of displacing water out of deeper strata and inadvertently moving it into shallower outcrops, subcrops, or into areas with potable water.

The best sites for carbon sequestration are those with saline reservoir strata that are overlain by structurally controlled oil and gas fields. These areas not only have structural closure, but, also have proven seals that mitigate against CO_2 leakage. The Ordovician age St. Peter Sandstone and the Cambrian age Mt. Simon Sandstone are the two most significant Illinois Basin targets for CO_2 storage in saline reservoirs. Using the shallow hydrocarbon producing fields as structural control, it is estimated that the St. Peter has a potential storage volume of 2,000 MMtonnes and the Mt. Simon could store up to 5,900 MMtonnes in these structural traps.

Outcrop Analogs and Sequence Stratigraphic Context of the First Cow Run Sandstone, (Late Pennsylvanian, Missourian), St. Mary's and Newell Run Oilfields, West Virginia and Ohio

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The First Cow Run sand has been the most productive reservoir in the Conemaugh Group in southeastern Ohio. The discovery well was drilled in 1861 on Cow Run in Washington County. The sandstone has a maximum thickness of 14 m and a porosity and permeability as high as 23.8% and 1770 mD. A linear, northwest-trending area of production 1.6-3.2 km wide and at least 32 km in length extends through the Newell Run field southeastward into West Virginia near the town of St. Mary's. A second linear Cow Run trend in this area strikes west-northwest, is 1-3 km wide and at least 45 km in length and includes the Chesterhill (Ohio) and Boaz (West Virginia) Oilfields.

Sequence stratigraphic analysis of 87 outcrops of the Glenshaw Fm (Lower Conemaugh Group) 130-150 km southwest of the oilfields indicates the presence of nine glacioeustatically controlled, fifth order sequences. Incised-valley fills from 20-35 m thick are occupied by LST/TST fluvio-estuarine strata, with individual channel-fills from 6 to 10 m thick. Well-developed paleosols formed on interfluves during sea level lowstands and facilitate recognition of sequence boundaries. They are readily distinguishable on caliper logs as cave or washout zones. Geophysical logs were correlated through the oilfields and paleoenvironments interpreted based on log patterns and comparison with outcrops.

It is suggested that the First Cow Run trends near St. Mary's formed as alluvial and possibly estuarine channel deposits that filled valleys cut by northwest-flowing, coastal plain rivers during one or possibly two glacioeustatic lowstands.

Thirty Years of Coal Production in West Virginia "Energy Crisis" to Present.

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In the 1970's demand for energy was high as a result of the Arab Oil Embargo. The price of coal was also high, but production was surprisingly low. In the 1980's prices moderated, but production steadily increased. The 1990's brought the Clean Air Act and production in the northern coal field stagnated while it grew rapidly in the south.

Areas and parts of the geologic section have been depleted of economically mineable resources due to decline in demand and other factors while other areas have become economically viable. Employment has declined steadily during the whole period; however there is currently an anticipated shortage of miners due to the retirement of the remaining workforce who were mostly hired in the 1970s.

Over the last 30 years, surface mine production has increased from around 25 percent of the state's total production to over 36 percent today. This percentage appears to be more or less steady over the last few years. Analysis of recent data suggests only moderate increases in annual production in the face of high demand.

Recently, Allegheny Energy announced that they would begin burning some Powder River Basin coal in their system in 2005.

Beginning in 1980, I have been involved in various attempts to understand the ups and downs of West Virginia coal production. During that time, some predictable trends have played out and some really surprising trends have developed.

Elevated Barium Levels in Bedrock, Eastern West Virginia: Cause for Alarm?

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Barium is a naturally occurring heavy metal that can have a deleterious effect on the cardiovascular system. EPA drinking water limits for barium have been set at 2 mg/L (~2 ppm). In 1997, geologists with the West Virginia Geological and Economic Survey began mapping and sampling bedrock, soil, and stream sediment under the auspices of the USGS-sponsored STATEMAP program. All samples are analyzed by commercial laboratory for barium and 48 other metals. Investigations have been concentrated in the Valley and Ridge province of eastern West Virginia. Middle Eocene igneous intrusives were an initial focus of the geochemistry but the study also includes Ordovician through Pennsylvanian sedimentary rocks. One of the first geochemical trends to emerge was the presence of elevated levels of barium in the majority of samples, regardless of stratigraphic unit. The background level of barium, from more than 600 samples grouped into 36 stratigraphic categories, is 110 ppm, considerably higher than the acceptable EPA standard. However, for this to be of concern, one has to demonstrate the transfer of barium from bedrock to drinking water. Bedrock barium levels were compared to statewide analytical results provided by the USGS Water Resources Division for samples of groundwater, spring water, surface water, stream sediment "fines," and fish tissue. Although bedrock barium content may be relatively high, the metal does not appear to move directly into waters in contact with rock. Rather, barium eroded from bedrock may first enter the hydrologic system in the form of finely disseminated suspended stream load.

Economic deposits of microbial methane in Upper Devonian fractured black shales

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Relatively recent microbial activity has generated economic deposits of natural gas within fractured Upper Devonian black shales along the shallow margins of the Michigan and Illinois basins, and potentially within the Appalachian Basin. Meteoric waters recharged regional Silurian-Devonian aquifer systems along the basin margins, during Pleistocene glaciation, and migrated vertically into the overlying organic-rich shales, significantly diluting basinal fluid salinities and creating an environment conducive to microbial methanogenesis. Antrim and New Albany shale formation waters, in the Michigan and Illinois basins, respectively, have positive $\delta^{13}C$ values for $CO_{2(g)}$ and dissolved inorganic carbon (DIC, >20‰), and high DIC concentrations (10-70 meq/kg), indicative of methanogenesis. The covariance of δD values for CH_4 and H_2O indicate methane was generated by CO_2 reduction in-situ with dilute fluids and adsorbed onto the organic matrix. Carbon isotope values of CH_4 range between suggested field for microbial versus thermogenic gas and in some cases are more positive than basin-centered thermogenic gas plays. Carbon isotope values of ethane and propane increase with decreasing concentration due to microbial oxidation of these thermogenic gas components. Selective enrichment cultures and DNA studies of Antrim Shale fluids show methanogens and acetogens associated with this unique gas resource. The fractured Upper Devonian Ohio Shale in the Appalachian Basin is thermally immature along the western and northern basin margins, and contains up to 11% total organic carbon. It is reasonable to assume that microbial gas has also been generated within the Ohio Shale at shallow depths, given the similar hydrostratigraphy and glacial history.

The Sevier-Knox/Trenton Total Petroleum System (Hypothetical)

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Black Ordovician shales, up to 7000 feet thick (Athens and Sevier Shales in Tennessee, and the Paperville Shale and Liberty Hall Formation in Virginia), occur along the eastern side of the Valley and Ridge Province. The Sevier and Paperville Shales constitute the largest mass of these potential source rocks and are generally over mature with respect to hydrocarbon generation (Sevier CAI ~ 3-4; Paperville CAI ~ 2.5-4). TOC analyses of Sevier and Paperville outcrop samples (n = 8) range from 0.04% to 1.08% (average = 0.37%).

Oil and gas are produced from Ordovician strata in Alleghanian structural traps in the western part of the Valley and Ridge, from the Swan Creek field in Tennessee, and from the Rose Hill and Ben Hur fields in Virginia. Furthermore, hydrocarbon occurrences have been documented along the top-of-Knox unconformity within the nearby Mascot-Jefferson City zinc district in Tennessee, and within biohermal buildups along the Middle Ordovician basin margin in Virginia. It has been postulated that the source of both the zinc ores and associated hydrocarbons in eastern Tennessee was the Sevier Shale, and that the source of the hydrocarbons in the Ordovician buildups in Virginia is the Paperville Shale. Given the large volume of these shales and the documented potential for early generation (Devonian?), it is possible that considerable amounts of hydrocarbons were generated from these strata and have migrated long distances westward to where they are preserved in Lower Paleozoic stratigraphic traps and in large extensional structures in the deep, relatively undeformed Plateau region of the Appalachian basin.

Illinois Basin Coalbed Gas: Is there a play?

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Coalbed gas plays often follow a pattern from scattered reconnaissance wells to minimal pilot tests, often dragging on for years. Then, a threshold is crossed. A technological advance, a fortuitous break, enough wells drilled, or a determined operator finally leads to a success. Then, the number of wells drilled will increase dramatically and the play blossoms. Is the Illinois Basin coalbed gas play at such a point? Drilling has been accelerating recently.

Early investigations suggested that the Illinois Basin suffered from thin, low gas content, tight coals. Recent mapping, coring, and testing have shown that view to be pessimistic, however. The average aggregate thickness of seams >1.5 ft. is more than 15 ft., and multiple seams are consistently 3–5 ft. thick over wide areas. Measured gas contents typically range from 60–115 scf/t, and as high as 175 scf/t (dmmf). Recent pressure transient tests indicate permeability from 3 to 200 mD. Minor thermogenic and dominant secondary biogenic methane, and appreciable nitrogen fractions are present in the sorbed gas, suggesting a complex geologic history.

The "right" stimulation design for these coals has not yet been found. Most wells have used off-the-shelf stimulations. Air drilling, nitrogen fracs, radial pulse fracs, or other innovative techniques have yet to be tested. Horizontal or multi-lateral wells may lead to commercial success. The nature of these coals suggests that gas production rates and recoveries will likely be moderate at best, so synergistic development with other opportunities may be necessary for economic success.

Coalbed Methane Research Drilling in Illinois- New Data

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Coalbed gas testing of major coals in two new wells drilled in eastern Illinois by the Illinois State Geological Survey (ISGS) indicate potential for commercial production in this evolving play. The James Cantrell, #9 Hon well in northeastern White County cored seven coals totaling 24.5 feet from the Danville through Davis coals at depths from 756 to 1114 ft. Coal gas contents (dmmf) range from 78 to 129 scf/ton. Desorbed gas compositions range from 60 to 82% methane, 16 to 37% nitrogen, and 1.2 to 2.0% CO_2. Methane saturation ranges from 40 to 64%. Pressure transient tests in the Hon #9 coals indicate permeabilities of 3 to 200 mD, with all but one value in the 3 to 35 mD range. A pilot production program will be developed here to evaluate water flush, nitrogen frac, and slickwater stimulation treatments with varying flow rates and amounts of proppant.

In southeastern White County, ISGS drilled 33 feet of coal in the Howard Energy, #C-1 Wassem well and cored 8 coals from the Danville to the Mt. Rorah at depths from 387 to 966 ft. Gas contents range from 75 to 112 scf/ton (dmmf). Desorbed gas compositions range from 69 to 96% methane, 0.5 to 31% nitrogen, and 1.2 to 2.8% CO_2. Methane saturation ranges from 24 to 92%. Carbon and deuterium isotopes suggest the desorbed methane from both wells is primarily biogenic in origin. Possible coal oxidation in canisters may have lowered methane and boosted nitrogen composition values for both wells.

Thermal History of the Central and Southern Appalachians from Apatite and Zircon Fission-Track Analysis

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Fission-track (FT) ages have been determined for >160 samples from the Allegheny Plateau, Valley and Ridge, Blue Ridge, and Piedmont provinces in West Virginia, Maryland, Virginia, District of Columbia, Tennessee, North Carolina, and South Carolina. The data provide an overview of Phanerozoic burial and exhumation over a large region.

In the eastern Blue Ridge and Piedmont, most rocks were buried to temperatures high enough to totally anneal zircon (>~240°C) prior to cooling during the late Paleozoic Alleghanian orogeny. In the eastern Blue Ridge, zircons yield remarkably uniform ages, ranging from ~300 Ma in northern Virginia to ~280 Ma in Tennessee-North Carolina, that reflect rapid cooling, most likely during emplacement and rapid denudation of Alleghanian thrust sheets.

In contrast, rocks from the Valley and Ridge and Allegheny Plateau, which yield zircon FT ages equal to or greater than the depositional age of the rocks, have never been buried to temperatures high enough to totally anneal zircon, and some may have undergone little, if any, annealing.

Apatite FT data indicate that rocks across the region cooled below 90-100°C (the apatite FT closure temperature) between ~90 Ma and ~200 Ma. Apatite ages are youngest in the eastern Valley and Ridge, and become older east towards Washington, D.C., and west towards Frostburg, MD. The age distribution is interpreted as reflecting flexural uplift and differential erosion. In the Blue Ridge, where elevation differences are sufficient to obtain a relief section, apatite data suggest effective denudation rates of ~20 m/m.y. since the late Triassic-early Jurassic.

CO_2 Sequestration in Gas Shales of Kentucky

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Continued economic growth will depend on the availability of reliable energy. Improved efficiency and alternate energy sources will reduce total CO_2 emissions, but carbon capture and storage are required to meet goals of stabilizing CO_2 in the atmosphere. Continuous, low-permeability, fractured, organic-rich gas shales are a possible sequestration target.. Devonian shales underlie approximately two-thirds of Kentucky. These shales are the source and trap for large quantities of natural gas. Enhanced natural gas recovery may be possible as stored CO_2 displaces methane.

Drill cuttings and cores from Kentucky, West Virginia, and Indiana were sampled, and adsorption isotherms collected. Sidewall core samples were analyzed for their potential CO_2 uptake and resulting methane displacement. Digital well logs were used to model TOC and CO_2 adsorption capacity. Average random vitrinite reflectance data range from 0.78 to 1.59, the upper oil to wet gas and condensate maturity range. TOC ranges from 0.69 to 4.62 percent. CO_2 adsorption capacity at 400 psi ranges from 19 to 86 standard cubic feet per ton of shale.

Initial estimates based on these data indicate a sequestration capacity of as much as 28 billion tons in the deeper and thicker parts of the Devonian shales in Kentucky. New estimates based on adsorption and geophysical log data are being compiled. Should shales prove to be a viable geologic sink for CO_2, their extensive occurrence in Paleozoic basins across North America would make them an attractive regional target for economic CO_2 storage and enhanced natural gas production.

Outcrop Analog For Lower Paleozoic Hydrothermal Dolomite Reservoirs, Mohawk Valley, New York

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This study focuses on an outcrop in the Mohawk Valley, New York where field mapping, a 3D-Ground penetrating radar survey, petrography, geochemistry, and cores all show a clear link between wrench faulting, brecciation, and hydrothermal alteration in the Lower Ordovician Tribes Hill Formation (Beekmantown Group). Fault-related hydrothermal alteration features include: fracture-, vug- and pore-filling saddle dolomite, chalcedony, anthraxolite, calcite, sphalerite and pyrite, matrix dolomitization around faults and fractures. It is a scaled analog for Trenton Black River hydrothermal dolomite reservoirs of the eastern United States. This outcrop may help better understand brecciated and dolomitized oil and gas reservoirs in time-equivalent Beekmantown/Knox and Ellenburger Group carbonates as well.

The outcrop has an left-stepping *en echelon* fault pattern and a similar, though not identical *en echelon* distribution of elongate dolomite bodies. A 3D Ground penetrating radar survey of the quarry floor has helped to map out faults, fractures, folds and the extent of dolomitization. Most of the dolomitization occurs in normal fault-bounded synclines or "sags". Dolomite only occurs around the faults and is absent away from faults and fractures. New core data confirms this. The dolomite structures begin and end at saddle dolomite-cemented breccia-tips. The breccias were produced by faulting and thermobaric fluid flow. We are beginning to map classic strike-slip features: forced folds, Riedel and P-shears, scissor faults, inline grabens, and oblique-slip fault segments. The feature may be part of a larger strike-slip fault system in the Mohawk Valley.

Coal Washability Data Trends in Eastern Kentucky

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Economic development of eastern Kentucky coal resources is increasingly affected by the quality of the remaining coal deposits. Much of the coal currently being mined in that region must be processed to reduce sulfur and ash content to meet contract specifications. In recent years, the Kentucky Geological Survey has acquired significant numbers of industry coal-quality data, many of which include washability and bench analyses in addition to standard whole-seam proximate data.

The objective of this study was to study washability behavior with respect to geographic and stratigraphic variation, in order to develop a classification of Kentucky coals based on these properties. Three coal-quality data sample sets for eastern Kentucky were selected on the basis of availability of information. Washability data and raw quality data were analyzed by coal bench, and average sulfur, ash, and Btu values were recorded. Washability data were then compared to raw quality data, and changes in sulfur, ash, and BTU's were analyzed. Data from all three sample sets were then compared to assess trends. Linear reductions in ash in most coal benches were standard, whereas sulfur changes were highly variable. Linear reductions in sulfur occurred in some benches, whereas, an increase in sulfur occurred in others, presumably related to variable composition of the ash fraction.

Case Histories: Frac Fluid Recovery Improvements of Appalachian Basin Tight Gas Reservoirs

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The primary purpose of nonionic surfactants used in stimulating sandstone reservoirs is to reduce surface tension, contact angle and emulsion tendencies. However, many of these chemicals adsorb rapidly into the sandstone formation, reducing their effectiveness of post frac fluid recovery.

This study describes the laboratory experiments and field case studies of various surfactants used in the oilfield. Several different surfactants including ethoxylated linear alcohol, nonyl phenol ethoxylate and a microemulsion system were investigated to determine their adsorption properties when injected into laboratory sand-packed column. A laboratory simulated comparison study of ethoxylated surfactants and microemulsion was used to identify their water recovery properties from gas wells.

Field data collected from Benson, Balltown, Injun, and Speechley sandstone formations confirms experimental sand packed column and core flow investigations. Reservoirs treated with microemulsion fluids demonstrate exceptional water recoveries when compared with conventional non-emulsifying surfactant treatments. Wellhead pressures, flowing pressures and production data were collected and evaluated using a production simulator to show effective frac lengths and drainage areas with various fluid/surfactant systems. These investigations and presented case studies can be used to optimize chemical treatments. The primary objectives of this study include:

1. Comparison studies of the microemulsion system with conventional ethoxylated surfactants commonly used in the oilfield to determine their adsorption properties into the proppant pack, surface tension and water recovery.
2. Experimental data comparing effectiveness of conventional surfactants and microemulsion in non-emulsification, regain permeability, and fracture clean up test.
3. Case studies and production simulations where microemulsion treatments have improved water recoveries in treated gas wells of Benson, Balltown, Injun, and Speechley formations.

Field data collected from several gas wells stimulated in Appalachian Basin reservoirs illustrates that the microemulsion added to frac fluid exhibits significant advantage over the conventional surfactant treatments when water recovery and increased effective frac length and well productivity are of concern to the operator.

Geology 101: The Discovery of the Billy (Abo) Field, Lamb County, Texas

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Wagner & Brown, Ltd., with its partner Burlington Resources, spudded the Billy C #1 well in November 1994. This well was completed flowing 37 barrels of oil on January 13, 1995 and is the discovery well for the Billy (Abo) Field. The Billy (Abo) Field is located in southern Lamb County, south of the town of Littlefield, and produces from the Leonardian Abo formation. Production in and around the discovery had only occurred previously from overlying San Andres and Clearfork formations. To date, the Billy (Abo) Field has produced 1,543,303 barrels of oil.

The Abo formation is a time-transgressive formation of early to middle Leonardian age. Early Leonardian depositional geometry in the northern Permian Basin was that of a rimmed shelf margin. Several outcrop and subsurface studies have documented the existence of well-defined continental, sabkha/supratidal, intertidal, subtidal, and basinal environments along the northern rim of the Permian Basin. These same facies tracts are very evident within the 2,000 plus feet of core taken from 19 wells within the Billy (Abo) Field. These cores were studied in great detail to determine the depositional environments and porosity types as they relate to production and subsequent exploration. The main producing intervals in the Billy (Abo) Field are interpreted as intertidal peloid grainstones deposited in tidal channels or as bars and shoals along the paleo-shoreline.

Overall porosities in the Abo reservoirs of the field range from 2% up to over 30%, with the average being around 12%. Porosity varies greatly from facies tract to facies tract. As examples, the depositionally high intertidal to supratidal facies have been heavily occluded with anhydrite, greatly diminishing their porosity values.

The grainstones of the intertidal facies were dolomitized very early and have been subjected to a later stage diagenetic event that has leached out some of the dolomite rhombs, enhancing the porosity. The better porosity in the subtidal facies tract is interparticle and intraparticle (moldic) porosity. This porosity type is a good producing facies when found above the field's oil-water contact of –3200 ft.

Greenhouse, Transitional and Icehouse Eustasy Yield Distinctive Parasequence and Sequence Stacking on Carbonate Platforms

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Greenhouse platforms consist of stacked, meter scale parasequences capped updip by tidal flat facies and subtle disconformities; downdip they have poorly cyclic subtidal units. Parasequences are precessional or even sub-Milankovitch. Third-order sequences are bounded by stacked disconformities. Icehouse platforms have disconformable fourth-order sequences (grossly 100 to 400 k.y) with local incision, and contain juxtaposed deep water and shallow water facies and rarely have tidal flat facies. The large sea level changes (50 m to 100 m plus) are driven by obliquity and eccentricity. Component parasequences may be shingled and contain local, high relief buildups. Platform margins may show considerable vertical shifts in depth sensitive facies. Third-order sequences are relatively subtle and tend to be masked by the dominant fourth order successions. Transitional states when the earth contained moderate amounts of polar ice have sea level changes of a few tens of meters or less. Platform successions contain well developed third- or fourth-order sequences dominated by shallow water facies and widespread carbonate sands, bounded by subtidal carbonate mudstones and variably developed regional disconformities. Parasequences (obliquity/short term eccentricity?) are a few meters thick and are bounded updip by disconformities and thin eolianites, but tidal flat deposits are relatively rare. Transitional states have been overlooked and occupy a substantial part of the record. Reservoirs on greenhouse platforms are early peritidal dolomites, or shelf edge grainstones. On transitional and icehouse platforms, reservoirs include widespread grainstones that extend into the interior, and on-platform buildups on icehouse platforms.

Developing New Advances in 3D Seismic Interpretation Methods for Fractured Tight Gas Reservoirs

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Natural fractures are predicted using seismic lineament mapping in the reservoir section. A seismic lineament is defined as a linear feature seen in a time or horizon slice through the seismic volume that has a negligible vertical offset. Seismic attributes investigated may include coherency, amplitude, frequency, phase, and acoustic impedance. Volume based structural curvature attributes may also be computed. It is interpreted that areas having high seismic lineament density with multi-directional lineaments define areas of high fracture density in the reservoir.

Lead areas are screened by seismic attributes, such as seismic amplitude or acoustic impedance, indicating brittle reservoir rock that are more likely to be highly fractured. Seismic attributes are calibrated to clay content measured in existing well control by wireline logs.

Gas sensitive seismic attributes such as the phase gradient (an AVO attribute developed by GeoSpectrum) or frequency dependent seismic amplitude may be used to define a prospective fairway to further screen drill locations having high gas saturation. These attributes may be calibrated to gas saturation determined from existing well control by wireline logs. Reservoir fractures enhance reservoir permeability and volume; they may also penetrate water-saturated zones and be responsible for the reservoir being water wet and ruined.

In a gas field previously plagued with poor drilling results, four new wells were spotted using the methodology and recently drilled. The wells have estimated best-of-12-months production indicators of 2106, 1652, 941, and 227 MCFGPD. A prospect rating system is developed indicating either a "good", "average", or "poor" grade.

Oil and Gas Reserves Estimating — *We Have Met the Enemy, And He is Us*

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The presentation will commence with several audience exercises contrasting deterministic estimating with probabilistic estimating, as the foundation of the body of the paper.

Regardless of whether predictions are expressed *deterministically* (single-number forecasts) or *probabilistically* (as ranges of forecasts corresponding to perceived probabilities), they are still estimates, subject to vagaries of nature, human error, and various biases. But probabilistic estimating has five important advantages:

1. Forecasting accuracy can be measured;
2. Use of statistics improves estimates;
3. Reality checks can pre-detect errors;
4. It is faster, more efficient, avoids false precision; and
5. It promotes better communication of uncertainty to decision-makers and investors.

However, using prevailing practices that have evolved through decades of engineering practice, reinforced by SEC-approved standards, "Proved Reserves" is a deterministic number that refers to a specified volume (or more) of hydrocarbons that the estimator is "reasonably certain" will be recovered from a well, property, field, or district. Even so, it is actually a probability statement, *except that no confidence-level (= probability) is specified*. It is up to the individual reserves appraiser to sense his/her "reasonable certainty", and in fact, experience indicates that individual "reasonable certainty" ranges widely. Accordingly, proved-reserves estimators cannot be accountable. Reserves estimates are also susceptible to bias because appraisers may be aware that larger proved-reserves estimates may benefit the value of their own shares, annual bonuses, repeat business, or organizational status. On the other hand, various negative career and legal consequences may ensue if the "reasonably certain" estimate turns out to be larger than the actual outcome. To say that all of this constitutes a self-made, illogical, and insupportable professional conundrum is a severe understatement!

Today, Petroleum E&P is a divided industry: during the late 1980's and early 1990's, Exploration adopted probabilistic methods as best-suited for estimating recoverable volumes of oil and natural gas from drilling prospects and plays, given discovery. But the Production side of E&P generally remains stuck in the old rut of deterministic methodology, even though it is demonstrably inferior.

A simple remedy would facilitate the transition to probabilistic methods for the entire E&P Industry: for members of all professional geotechnical and engineering societies to specify that when they use the term "proved", they are explicitly affirming 90% confidence in their estimates, regardless of outmoded and illogical SEC definitions. This would immediately allow measurement and accountability, and would lead eventually to the adoption of full probabilistic methods throughout the E&P industry. Such assertive leadership has yet to emerge from the professional associations, however.

Ill-defined reserves standards, as well as misaligned corporate incentive schemes, organizational coercion, and motivational bias, all tend to encourage unethical behaviors in reserves estimating. Constant focus by individuals and companies on recommended practices, professional standards, and personal ethics are essential for consistent and reliable results.

Burial and Thermal History Models of the Central Appalachian Basin, Ohio, Pennsylvania, and West Virginia

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Three models of burial and thermal history have been developed for the undeformed north-central Appalachian basin based on regional-scale, 2D cross-sections. The models integrate thermal and geologic data to provide the most accurate possible burial, uplift, and erosion history. The cross-sections extend from the Allegheny structural front in West Virginia and Pennsylvania northwestward across the Rome trough and terminate on the Findlay Arch in northwestern Ohio.

The models incorporate sedimentation, compaction, uplift, and erosion, and assume a constant basement heat flow of 52 mW/m^2. Relatively low thermal conductivities are assigned to Pennsylvanian coal beds (0.2 W/mºC) and to Devonian kerogen-rich shales (0.9–1.2 W/mºC), based on published values from the region. The models are constrained by corrected bottom hole temperatures and by measurements of conodont color alteration index (CAI) and vitrinite reflectance (R_o%) from Ordovician, Devonian, and Pennsylvanian rocks. To match the measured thermal maturities, the models require deposition of additional Permian-Triassic sediment, subsequently removed by erosion. We assumed that maximum burial occurred during the Triassic with deposition of a wedge of sediment, ~7700 ft thick at the southeast end of the section and thinning northwestward. The burial/thermal history models permit the thermal maturities of individual hydrocarbon source rocks to be calculated across the region. The models also provide the regional-scale temperature and pressure framework needed to model hydrocarbon migration.

In Search of a Silurian Petroleum System in the Central Appalachian Basin

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Oil and gas accumulations in Silurian reservoirs in the central Appalachian basin have yet to be conclusively correlated with a source rock. The Ordovician Utica Shale, which underlies these accumulations and has high total organic carbon values (TOC~1.5-4.0 wt. %), is most commonly cited as the source rock. However, other source rocks may exist, such as overlying Devonian black shale and Silurian shale and carbonate.

To evaluate the source rock potential of Silurian strata, well cuttings (n=302) and core (n=6) were sampled in NY, OH, PA, and WV and analyzed for their TOC content and RockEval parameters. The following strata were sampled: the Lower Silurian Cabot Head Shale, Rochester Shale, and Rose Hill Formation; and the Upper Silurian McKenzie Formation, Lockport Dolomite, Wills Creek Formation, Tonoloway Limestone, and Salina Group.

Most samples (n=280) have TOC values that are too low (~0.20-0.49 wt. %) to qualify as a source rock. However, 23 samples are fair source rocks (TOC =0.50-0.99 wt. %) and 5 samples are good to very good source rocks (TOC=1.00-3.35 wt. %). The highest TOC values were measured in 150- to 500-ft-thick intervals of anhydritic dolomite and(or) gray limestone with thin black shale interbeds in the Salina Group in northwest Pennsylvania (Butler County) and in the McKenzie and Wills Creek Formations and Salina Group in northern West Virginia (Hancock, Monongalia, and Preston Counties). We conclude that although local source rocks are present in Silurian strata, they are too lean and too widely dispersed to constitute a major petroleum system.

Workstation 101 and How to Find Consulting Work

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The life of the consultant has changed dramatically in the last 10 years. PC Workstations have become more affordable and the geological and geophysical software packages developed for use on a PC are very competitive with their UNIX counterparts.

This presentation will compare hardware and software costs for PC versus UNIX workstations, and demonstrate how a geoscientist wanting to get into the consulting world can set up and grow their business.

Starting out on your own is not an easy thing to do. If you plan on doing any geological mapping or seismic interpretation, probably a computer workstation of some sort will be necessary. Therefore, the following issues will be important points to consider: 1) buying a "canned" machine, or building a clone; 2) buying software; 3) maintenance issues, PC vs Unix; 4) advantages of using PC's for seismic interpretation; 5) speed of machines and capacities – Myths and Truths; 6) seismic interpretation packages on the market are easier to learn, more intuitive, and have the same functionality as the Unix versions; 7) selecting plotters and printers; 8) costs of typical equipment for a geophysical/geological workstation. One could easily build a state-of-the-art geophysical workstation for around $6000.

To find consulting work, become an "Expert" in your software package; become familiar with the small independents in town; NETWORK, NETWORK, NETWORK; join additional Organizations/Social Clubs; if you are not risk-aversive, build your workstation, and "THEY WILL COME;" volunteer time in your organizations; put together "presentations" and hit the speaker's circuit; when you do work for a client, do the best job you can – and charge fairly; and finally – do good deeds for other people along the way!

Evaluating Controls on the Formation and Reservoir Architecture of Niagaran Pinnacle Reefs (Silurian) in the Michigan Basin: A Sequence Stratigraphic Approach

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Silurian-aged, Niagaran (or Guelph) pinnacle reefs have been productive in the Michigan Basin for more than 60 years, but extensive lateral and vertical heterogeneity has limited primary production efforts, resulting in estimates of stranded hydrocarbons as high as 75%. Enhanced recovery efforts are generally focused on water and CO_2 floods, along with horizontal drilling, but the connectivity of the reefs in both lateral and vertical dimensions has been unpredictable. Evaluating the pinnacle reefs with a sequence stratigraphic approach has provided a framework for understanding and predicting the vertical compartmentalization of these reefs.

Based on reservoir-scale observations, restriction of water circulation related to changes in relative sea level was a major controlling mechanism on the vertical facies distribution. Microbial mounds at the base of the reefs are interpreted as forming in a dysoxic environment related to initial flooding of the basin, while stromatoporoid reefs flourished during highstands when normal marine circulation was established.

Vertical facies patterns indicate a general shoaling upward sequence from microbial mound to reef core, followed by tidal and supratidal environments typically capped by impermeable exposure surfaces. The discovery of these vertical facies successions, each bounded by exposure surfaces and evidence of subsequent flooding, has challenged the current dogma of pinnacle reefs as being the result of continuous long-term growth in favor of a more likely episodic growth model. By identifying these cycle and sequence-scale vertical patterns, facies distribution and the resulting reservoir architecture can be better predicted in pinnacle reefs in the Michigan Basin and may also provide insight into similar structures in the geologic record.

Investigation of Brine Geochemistry and Implications for Geologic Sequestration of CO_2 in Deep Sedimentary Basins

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Major mechanisms for sequestering CO_2 in geologic formations include containment by caprock, trapping in residual phase, solution in formation brines, and reactions with minerals. These mechanisms operate at varying spatial and temporal scales, and their relative magnitude/importance varies based on site-specific conditions. An important aspect of assessing the long-term behavior and storage of CO_2 is the detailed geochemical characterization of in-situ formation fluids. A 9,190 ft–deep well was drilled to evaluate the CO_2 storage potential of the entire sedimentary sequence in the Appalachian Basin at the American Electric Power (AEP) Mountaineer Plant in New Haven, West Virginia. Important elements of the AEP borehole characterization program included: detailed hydrochemical sampling of brine (obtained from two sandstone formations, Rose Run and the basal sandstone), a comprehensive suite of geophysical wireline logging, core analysis, and reservoir hydrologic testing. Multiple sequences of dense, impermeable dolomite, limestone, and shale overlay and isolate the potential deep storage reservoirs in this area. Brine samples were collected shortly after borehole completion and again approximately seven months later during detailed hydrologic testing of selected formation horizons. Geochemical results obtained from the second sampling event are considered to be more representative of actual in-situ formation conditions, due to the removal of residual drilling fluid (and reversal of local chemical effects) during hydrologic testing activities. The hydrochemical results indicate that the formation brine waters are consistent with the sparse regional data for these formations, which in this part of the Appalachian Basin are of a Na-Cl or Na-Ca-Cl hydrochemical type. Brine concentrations for the two deep zones sampled at the AEP borehole also fall within the higher end of the dissolved solids range (200,000-325,000 mg/L) reported regionally for these formations. The main implication of high formation brine salinity is that the solubility, and therefore the reactivity of CO_2 with formation minerals, would be reduced. Therefore, the main storage mechanisms in such mature, deep basin formations would be containment by caprocks and residual saturation. Results from stable isotope analysis and other hydrochemical measurements indicate that the candidate storage formations at the AEP borehole are similar geochemically to other deep formations in the region and are isolated from overlying surface and groundwater. Geochemical modeling results do not indicate any adverse reactions that would have a negative impact on the injection of CO_2 into either of the candidate storage formations. The work presented here is being conducted under the Ohio River Valley CO_2 Storage Project, funded by U.S. Department of Energy, American Electric Power, BP, The Ohio Coal Development Office, Schlumberger, Battelle, and Pacific Northwest National Laboratory.

Fracture Pattern Analysis using FMI Logs of the Tensleep Formation, Teapot Dome, Wyoming

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This study presents a detailed analysis of fracture distributions and orientations in the Tensleep Formation along the axis of the Teapot Dome in northeastern Wyoming. Oil production from the Tensleep is restricted to a fault bounded culmination located on the southern part of the dome. 3D seismic data portray the major structural subdivisions of this basement cored uplift. The characteristics of fracturing in the Tensleep are inferred from FMI logs in wells distributed along the north-south trending axis of the dome. The Pennsylvanian aged Tensleep Formation is approximately 250 feet thick in the area. The formation was deposited in an aeolian sand/ sabkha evaporite environment and consists of a series of sand and dolomite intervals. Stereonets and rose diagrams of open fractures in the Tensleep reveal that fractures can be grouped predominantly into two clusters: one with vector mean strike of N71°W and a second with vector mean strike of N22°W. However, examination of fracture orientations in the lithologic subdivisions of the Tensleep reveals considerable variability from one unit to the next.

The Tensleep has relatively low permeability, averaging about 30 mD. Oil production is largely controlled by fracture connectivity and permeability. This study will be used to develop multilayer models of fracture properties. The National Energy Technology Laboratory code FRACGEN will be used to extend those descriptions into the surrounding region. Multiple realizations of possible fracture distributions will be derived in this study. These models will eventually serve as the basis for flow simulations of oil production.

Geochemical Exploration for Trenton-Black River Gas Reservoirs In New York and Ohio

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The innovative application of both organic and inorganic surface geochemical tools facilitates Trenton-Black River gas exploration and structural mapping in the Appalachian Basin. Concentrations of tightly adsorbed hydrocarbons in the fine fraction of soils are determined by thermal desorption and Flame-Ionization Detector Gas Chromatography (FID-GC). Major and trace element concentrations in the same fine fraction of soils are estimated by aqua regia acid digestion and analysis of the supernatant for 26 elements by Inductively Coupled Emission Spectroscopy (ICP-ES).

The interrelationship of C_1-C_6 hydrocarbons in soils is used to discriminate between "gas-prone" and "dry" areas. Discriminant analysis of C_1-C_6 hydrocarbon data reveals that the most important variables for distinguishing between these areas are, in order of importance, ethylene, isobutane, isopentane, methane and propane. Soils over the gas fields are characterized by anomalous C_1/C_2 ratios and light alkenes (i.e. ethylene and propylene), which is not surprising considering the dry gas composition of these hydrothermal dolomite reservoirs (i.e. >98% methane). A "Mississippi Valley Type" element association, which includes calcium, magnesium, strontium, zinc, and lead, is prevalent in soils over faults that crosscut or parallel gas reservoirs. Soils over the faults also show anomalous alkane/ alkene ratios. The results of geochemical surveys over shallow reservoirs in Ohio (1,400-1,500 feet) and deep reservoirs in New York (9,000-10,000 feet) will be presented to emphasize the value of these geochemical tools for exploration risk reduction and structural mapping.

Petroleum Potential for the Lower Paleozoic Strata in the Illinois Basin

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Devonian, Silurian and Ordovician reservoirs account for 7.5% of the petroleum produced in Illinois. These reservoirs represent a guideline to the potential for Lower Paleozoic production and the opportunity for new exploration targets in the Basin. Devonian reservoirs, both silicalistic and several types of carbonate, have been established though lightly explored. Silurian reservoirs, commonly associated with various reef settings, exhibit compartmental characteristics that extend both development and new play production. Non-reef Silurian production has also been established. Ordovician reservoirs are limited to the Trenton carbonate, closed structure fields leaving the prolific hydrothermal play as pure potential. The Lower Paleozoic units have not been extensively explored, in part because of the greater drilling depths and the practice of penetrating deeper horizons mostly in fields where shallower production has been established. This strategy has brought sporadic results because structural closure may shift with depth and numerous traps in Lower Paleozoic units are stratigraphic.

An Illinois Basin Consortium project funded in part by the U.S. DOE is focusing on existing petroleum reservoirs and the potential for new discoveries in Lower Paleozoic units. Major tasks for this project include creating a digital catalogue of existing reservoirs and developing models of the stratigraphic and structural framework of Lower Paleozoic units using available subsurface data. These products will be available in digital format on an ArcIMS website. Preliminary results suggest that applying new exploration strategies to the Illinois Basin can result in significant new discoveries in Lower Paleozoic units.

Wrench Fault Architecture of Trenton Black River Hydrothermal Dolomite Reservoirs

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Trenton –Black River hydrothermal dolomite reservoirs commonly occur in *en echelon* grabens associated with transtensional faults. These e*n echelon* grabens have historically been linked to Reidel Shear faults associated with an underlying strike-slip fault. Reidel shear faults "step" in the opposite direction of their sense of motion (i.e. right-stepping Reidel shears indicate left-lateral strike-slip).

Newly obtained 3-D seismic data suggests that the *en echelon* grabens at Rochester Field, Ontario, and York Field, Ohio, may not have formed between Reidel Shear faults. The structural highs and lows associated with the faults in these data sets appear to occur in the opposite quadrants of the fault zones that should occur with Reidel Shears. The grabens (and structural highs) in these data sets were most likely formed by right-stepping, right-lateral *en echelon* faults. The sense of step is the same as the sense of movement on the fault – the opposite of Reidel Shears. A good modern analog for this style of faulting is the Dead Sea transform fault system, which has deep basins forming where en echelon strike-slip faults overlap.

The origin of the fault architecture in these Trenton-Black River Fields is not currently understood but we have several working hypotheses: 1) the fields formed in transfer zones between extensional faults; 2) fault style was inherited from an earlier episode of faulting; 3) the faults initially moved as left-lateral faults and formed Reidel Shears and were then reactivated in a right lateral sense; or 4) some other model not currently under consideration.

Western Kentucky Precambrian Structure Map

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New deep-well and reinterpreted seismic data were used to remap the Precambrian structure of western Kentucky, resulting in new interpretations for the structure of the Rough Creek Graben. The graben is bounded by two east-west striking fault systems: to the north, the Rough Creek Fault System, and to the south, the Pennyrile Fault System. The graben is disrupted by the Central Faults, a series of northeast-southwest-striking faults. Fault motion along the Rough Creek faults is complex, but net motion is dominantly left-lateral strike-slip.

A series of structural irregularities and discontinuities were found when elevations of the Precambrian surface were contoured from reinterpreted seismic lines. Where these contouring irregularities coincided with trends of known surface faults, the faults were projected to basement to resolve the discontinuities. This has resulted in the placement of several new faults to basement within the graben. At least one of the faults crosses a seismic line and is substantiated by seismic data. These northeast-trending faults formed a series of small basins on the Precambrian surface, which influenced overlying sedimentation. Also, data from the Tarter well in Adair County extends the synclinal structure associated with the Rough Creek Graben eastward toward the Grenville Front, suggesting a possible connection with the Rome Trough in eastern Kentucky. This well penetrates the top of Mount Simon Sandstone at a depth of -5,696 ft, but does not penetrate the base of the unit, indicating that basement is deeper than previously projected in this area.

Multi-trace Curvature and Rotation Attributes- Application to Fractured and Hydrothermally Altered Reservoirs

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Modern multi-trace geometric seismic attributes include the well-known coherence technology, and new estimates of curvature and dip rotation. These attributes, which are generated from conventional P-wave 3-D seismic volumes, are especially useful in imaging rugose surfaces, and in identifying fracture zones, joint systems, small faults, and other features previously considered to be subseismic. In contrast to conventional attribute analysis, we generate a complete 3-D volume for each attribute, thereby eliminating interpretation errors involved in picking irregular surfaces that are so common in faulted and karsted terrains. The resulting multi-trace attribute volumes are loaded and interpreted within standard interpretation software packages. The attributes can be viewed in time slices, vertical sections and in extractions along picked horizons. Of special interest for operators in the Appalachian basin is the potential of these attributes to: 1) predict stress regimes and most likely azimuth of open fracture direction for any level within a 3-D survey, 2) map and quantify lineament density and azimuth through time, and 3) predict most likely areas of localization of fluid flow along faults that have a wrench component. We illustrate the calibration and application of these robust attributes to fractured, karsted and hydrothermally altered reservoirs in the Appalachian and other basins.

Porosity Evaluation of the Geneva Dolomite (Marion County, Illinois) Using Petrophysical Data

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Standard methods for evaluation of porosity in carbonate strata require modern porosity logs, i.e. density, neutron and sonic. However in mature reservoirs these logs are often rare or lacking. Such is the case in the Geneva Dolomite of the Grand Tower Formation (Devonian) in Marion County, Illinois. Although the Geneva has been a target of exploration for over 65 years, detailed studies of porosity distribution in this unit have not been undertaken. The lack of surface exposures of the Geneva has also limited such studies.

A petrophysical technique has been developed that permits determination of qualitative porosity in carbonate strata from a partial suite of porosity logs. The technique classifies porosity in carbonate sediments and ranks them from intergranular to vuggy. An investigation of porosity distribution in the Geneva Dolomite in Marion County, Illinois, was undertaken using this technique. Porosity determinations made by the technique show good agreement with core data from the Geneva, and with published data from other reservoirs. Results indicate a southwest to northeast trending zone of vuggular porosity across the study area. This technique has potential for the study of carbonates in both petroleum and groundwater exploitation.

The Appalachian Salina Deposits: Salt, Industry And Geologists

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The exploitation of the Appalachian Upper Silurian Salina Deposits has a unique history that reflects the evolving role of geologists in exploring resources in the Appalachian Basin. This paper addresses the relationship between geologists and the development of this salt resource since the late 1700's. The Salina Deposits formed in shallow evaporite seas where halite precipitated. In the Appalachian Basin, the salt sequences are up to 191 feet thick and now occur between 500 to 9,000 feet below MSL. The Colonial United States obtained most of its salt from European sources. During the revolutionary war, British embargoes limited salt supplies, spurring U.S. production. The concentrated brines along the Kanawha River (WV) became the main source of U.S. salt from the late 1700's through 1860. Exploitation of Kanawha brines led to development of drilling technologies to extract brines from subsurface "veins." These drilling techniques were later utilized throughout the Appalachians for the development of coal and petroleum resources. The salt industry matured in the late 1800's, when larger companies dominated, and solution and deep mining enhanced salt production. Appalachian salt production centers shifted to Buffalo, Cleveland, Pittsburgh and Charleston. In the early 1900's, the Chlor-Alkali industry (electrochemical production of chlorine, caustic soda and hydrogen from salt brine) stimulated salt production in Appalachia. Inexpensive hydroelectric power helped the Buffalo-Niagara region become a center for producing Chlor-Alkali and synthetic chemicals. Development of the interstate highway system in the late 1950's created a new demand for highway de-icing salt. Demand was met by increasing deep mining of Salina salts, which required preparation of environmental impact assessments for mining permits. The most recent association between the Salina Deposits and geologists resulted from the 1980's hazardous waste regulations. Wastes from synthetic chemical industries required geologists to modify their skills to assess and treat pollutants.

Treatment of a Chromate-impacted Water-bearing Unit in Ogallala Sediments, Southern Lea County, New Mexico

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A natural gas processing facility located in Southern Lea County, New Mexico had a historic release associated with cooling tower water that has produced a large chromate groundwater plume. The saturated zone hydrogeology is complex and located within the Tertiary Ogallala Formation. In the former release area there are three distinct hydrologic units that exhibit limited vertical connectivity. As the chromate groundwater plume migrates eastward the units thin, ultimately join and then the flow regime is dominated by the configuration of the relict erosion surface of the underlying bedrock that is comprised of the Triassic Chinle Formation. An in situ remediation program based on injection of a carbohydrate-mixture is being implemented at the site. In the former source area three distinct pilot programs are underway in each of the identified hydrologic units. At the distal end of the plume, an array of injection wells has been installed for groundwater plume cut off. Key elements in the injection program include hydrodynamics under batch and continuous injection and the life span of the injection reagents. The varying size of the chromate plume has recently be measured to be approximately 4,400 feet (1,341 meters) in length and to have a width of 1,400 feet (427 meters). Given the size of the plume and viable conventional surface based chromate treatment the application of an in situ solution offers site closure at significantly lower costs and less time.

New Model for Characterizing a Shallow Bedrock Aquifer in Central Lower Michigan- Heterogeneity and Discontinuity Dominates the System.

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Past studies of the Pennsylvanian Saginaw Aquifer suggested an incised valley fill relationship between the Grand River and Saginaw Formations comprising the aquifer. Recent findings supported by core analysis, wireline log correlation and biostratigraphic work reject previous models. The new model suggests a regression period dominated by deltaic deposition changing upsection to meandering stream complexes capped by transgressive estuarine conditions.

This model has important implications for aquifer heterogeneity both vertically and horizontally. Although, some coarse-grained channel sand units are as thick as 20-25 meters, lateral discontinuity of reservoir quality material is at a scale smaller than well spacing.

Water well data from a State of Michigan Geographic Information Systems database incorporated into this study supplies a proxy for core material where needed and water production data. This dataset pairs with oil and gas wells across the study area to allow hydrologic interpretations regarding the aquifer units.

Ongoing work will utilize the new regressive-transgressive model to delineate the spatial and geometric distributions of reservoir-quality aquifer units in this area. This is important due to increasing water consumption pressures from municipal and industrial sources in the region.

Characterization of America's "Engine Room" for Geologic CO_2 Sequestration

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Reducing greenhouse gases, while meeting the growing demand for fossil-fuel-generated energy, is dependent on rapid development of carbon-sequestration technologies. The Midwest Regional Carbon Sequestration Partnership (MRCSP) has been created to assess the technical, economic, and social merits of carbon sequestration. The MRCSP (one of seven regional centers formed under U.S. Department of Energy funding) brings together academic, industrial, and governmental partners from Indiana, Kentucky, Maryland, Michigan, Ohio, Pennsylvania, and West Virginia.

The MRCSP provides a unique and important opportunity for the development of carbon- sequestration technologies, in consideration that member states are a major source of CO_2 emissions and have enormous geologic assets for mitigation. This economically critical area represents 16% of the U.S. population and GNP and nearly 22% of the nation's electricity generation. The large industrial and power-generating point sources in the region produce about 715 million tons of CO_2 annually. 77% of electricity in the region is produced from coal-fired plants. Technologies are rapidly being developed to capture flue gas from coal-burning power plants and to extract/compress CO_2 emissions into an injectable liquid.

The region's diverse geology provides myriad opportunities for utilization or storage of CO_2. The region includes 3 major sedimentary basins, intervening arches, a coastal plain, and a fold-and-thrust belt. Such a range in depositional environments provides many sequestration opportunities. Huge potential exists for sequestering CO_2 in deep saline aquifers, deep unmineable coals and organic shales, and depleted oil-and-gas reservoirs. The MRCSP is producing regional geologic and petrophysical maps to support planning efforts and capacity calculations for the various sequestration technologies.

Managing Environmental Risks Associated with Gas Production in the Vicinity of Suburban and Rural Development

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Powerful risk evaluation and management practices, when routinely employed by petroleum companies, can dramatically reduce the incidence and severity of conflicts with emerging residential or agricultural owners where such land uses are starting to occur in the same areas. Suburban and rural residential and pseudo-agricultural land uses are increasingly encroaching on areas that have been primarily open land or resource extraction. In many cases, the mineral estate is severed from the surface, creating opportunities for conflict without the traditional "incentive" that royalty holders enjoy. It is incumbent on the industry to adopt and implement pro-active management and development practices in order to minimize the evident problems in such areas. The alternative is a combination of litigation and regulation, neither of which is less costly or time consuming, and whose effects are recognized to be more uncertain than the practice of risk reduction.

The adverse effects of failure to plan and implement such management practices, as well as the benefits of doing so, are presented in this paper. Examples, primarily from the western U.S., but applicable to all areas of the country, are given related to tight gas exploration and development, gas plant operation, and coal bed methane development.

A Reevaluation of the Silurian Burnt Bluff Group, Michigan Basin through Sedimentologic and Paleoecologic analysis

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The Middle Silurian Burnt Bluff Group has produced over 50 BCF of Natural Gas from several isolated fields in the northeastern and western-central portions of the Michigan Basin. Very limited geological studies exist for these potentially significant hydrocarbon producing strata.

The Burnt Bluff Group was deposited as a shallow carbonate ramp during the Early Middle Silurian in the Michigan Basin. The Burnt Bluff Group is composed of three formal Formations: the older Lime Island Formation, the Byron Formation and the younger Hendricks Formation. The Burnt Bluff Group thins to the south of the outcrop belt and pinches out in the subsurface near the midline of the Lower Peninsula.

The Lime Island formation was deposited above effective storm wave base with graded skeletal storm beds interbedded with bioturbated, skeletal wackestones. Fossils include pentamerids, favositids and stromatoporoids, representing normal open marine conditions. The Byron Formation consists of restricted lagoonal deposits containing ostracodes and gastropods and humid tidal flat deposits. The Hendricks Formation has local tabulate-stromatoporoid patch reefs with background deposition of bioturbated, skeletal, mud-rich packstones of the mid-shelf environment. Patch reefs of the Hendricks Formation are natural gas reservoirs in the northeastern Lower Peninsula, although most production is from the deeper water facies in the mid-basin open-shelf deposits similar to the overlying Manistique Group. More basinward Burnt Bluff lithologies consist of bioturbated skeletal wackestones with skeletal storm lags and have been extensively dolomitized.

Diverse floral and faunal elements suggest open marine conditions were prevalent over most of Burnt Bluff Group time. In addition, isotopic data from pentamerid brachiopods are similar to values derived from brachiopod material of other portions of the Silurian world and confirm that the Burnt Bluff Group was deposited under normal marine conditions.

Cretaceous and Tertiary Coal-bed Gas Resources in the Gulf of Mexico Coastal Plain

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Coal-bed gas is currently produced from multiple coal zones (3-6 m, 10-20 ft thick) within the Olmos Formation (Upper Cretaceous) of the Maverick basin in south Texas, and from the Wilcox Group (Paleocene-Eocene) of north Louisiana. In addition, there are numerous untested coal beds that potentially contain coal-bed gas resources in Cretaceous and Tertiary strata across much of the Gulf of Mexico Coastal Plain. Although the Olmos Formation is limited in extent to south Texas and northeastern Mexico, the Wilcox Group is coal- and presumably gas-bearing across much of the Gulf Coastal Plain. Depths to the targeted Olmos and Wilcox coal beds range from 450 to 600 m (1,500-5,000 ft). Measured gas content of the Olmos coal beds is as much as 8.5 cm^3/g (300 standard cubic ft per ton [scf/t] dry, ash-free basis, [daf]) and as much as 6 cm^3/g (213 scf/t daf) for Louisiana Wilcox coal beds. Gas production from the Olmos coals was initiated in 2001 and has remained fairly low. In 2004, it averaged about 137,000 m^3 (4,850 thousand cubic feet, MCF) per month from several dozen wells. Recently completed wells in Wilcox Group coal zones in north Louisiana have initial production ranging from 200 to 6,500 m^3 (7-230 MCF) of gas per day, which indicates that Wilcox coal beds may be more productive than those of the Olmos Formation. However, optimum completion methods and excess water production from adjacent water-bearing sandstones remain as obstacles for Wilcox coal-gas development.

In addition to the Olmos and Wilcox coal intervals, coal-gas resources may occur in the Lower Cretaceous coal beds of Arkansas and Louisiana. Drill records indicate that there are coal beds greater than 3 m (10 ft) thick at depths of 450 to 1,830 m (1,500-6,000 ft) in south-central Arkansas and northern Louisiana. Coal zones in the Eocene Jackson and Claiborne Groups may also be gas bearing at depth across much of the Gulf region; more data are needed to evaluate the resource potential for the Lower Cretaceous and Eocene coal zones.

Kentucky's Online Geologic Map and Information System

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Online oil and gas information for Kentucky has been the most frequently used data service on the KGS Web site. Anecdotal reports indicate that petroleum companies are increasingly relying on the easily accessible well and geophysical log reports. This year, with the completion of a project to digitize all of the state's 1:24,000-scale geologic maps, KGS is developing a geologic map service to complement their tabular databases. The new service will integrate geologic maps, including rock units, faults, structure contours, and economic beds, with well data and other locations for measured sections, samples, and photographs.

The Web service will allow users to construct a highly customized map of geologic, energy, mineral, and environmental themes. Derivative classifications of rock units, such as dominant lithology or karst potential, will be provided as an alternative to stratigraphic symbolization. A bookmark function will store the extent and layout of a particular map so that users can recall it at a later time. The Web map also has query tools that retrieve descriptions of rock units, as well as a variety of economic, geotechnical, hydrologic, and energy-related subjects. Databases of publications, wells, and analyses can be searched to find additional data that pertain to the map view.

Geologic CO_2 Sequestration – An Introduction

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Concern about the alleged relationship between increasing atmospheric concentrations of carbon dioxide (CO_2) and global climate-change continues to grow in the United States. Worldwide interest in this topic also is heightened, and many nations are passing new emissions laws and imposing “carbon” taxes to reduce the amount of CO_2 released into the atmosphere from anthropogenic sources. Sequestering CO_2 emissions in geologic reservoirs is a promising way to safely manage carbon for long periods of time.

Potential CO_2-sequestration targets include producing and depleted oil-and-gas fields, unconventional oil-and-gas reservoirs, unmineable coal seams, and saline aquifers. As part of on-going research, these potential CO_2 “sinks” are being characterized to determine their quality, size, and geologic integrity. A large number of pilot injection projects are slated to begin over the next few years. The petroleum industry’s vast experience in characterization, drilling, completion and injection will be needed as this technology progresses.

Large portions of the energy sector’s, and federal government’s R&D funds are now directed at greenhouse-gas capture and sequestration. Many local petroleum professionals have heard of geologic CO_2 sequestration, but few have taken the time to investigate what research is taking place and why. This presentation is meant to provide a brief introduction to the topic.

Geology and Geometry, A Geological Perspective on Maximizing Performance of Hydraulic Fractures

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Thousands of wells are hydraulically fractured in the Appalachian Basin each year. The stimulation treatment design is generally seen as an engineering discipline. Recent advances in understanding the dependence on both geology and the geometry of the created hydraulic fracture suggest that major improvements can be made in well performance. In order to optimize spacing and efficiently drain a field in mature or immature areas, the geologist must understand fracture orientation and geometry. It is equally important that an infill well is not placed in an existing well’s drainage pattern.

This paper will illustrate how a geologist might analyze a particular geological target and understand how the fracture design should be modified to maximize the effectiveness of the stimulation treatment. Many geological features of the particular target such as permeability, faults, natural fractures, etc. and the orientation of these features in relation to the regional in-situ stresses can significantly affect the results of a stimulation treatment.

Case specific examples will be outlined and utilized to illustrate the result the geological characteristics can have on the geometry and dimensions of the created hydraulic fracture.

Results of the first Micro-Seismic fracture imaging of an Appalachian Basin stimulation will be discussed and reviewed to demonstrate what the state-of-the-art is regarding the understanding of creating hydraulic fractures.

A GIS Based Sequence Stratigraphic Analysis of the Mississippian Big Lime, West Virginia, U.S.A

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The Mississippian Big Lime (Greenbrier Group) of West Virginia is a 100 to 1600 feet thick succession of mixed carbonate-siliciclastic sediments that formed on the Appalachian foreland. It provides an outcrop and subsurface analog to better understand Mississippian three-dimensional facies distribution, reservoir stacking patterns, and the stratigraphic signature of global greenhouse to icehouse conditions within an active foreland setting. Well-cuttings and wireline logs from 200 relatively shallow wells throughout West Virginia were analysed utilizing GIS. Fifteen regional fourth-order sequences were mapped throughout the subsurface, and time-slice maps produced. Lowstand-early transgressive tracts on the ramp consist of a complex mosaic of redbeds adjacent tectonic highlands, barrier sands along the ramp margin, and lagoonal shales and quartz peloid grainstone eolianites. Highstand tracts consist of widespread lagoonal carbonate mudstone, interspersed with three variably developed ooid and skeletal grainstone belts located along the ramp margin, within the lagoon, and along the updip shoreline; the ramp margin facies pass downdip into dark skeletal wackestone and then into dark gray laminated argillaceous carbonates. Thickness trends and complex distribution of grainstone facies and re-entrants in the margin suggest a tectonic control on facies distribution associated with the complexly faulted foreland, while the major sequence development reflects 4th order eustasy driven by waxing and waning of Gondwanan ice-sheets. This sea level control is further evidenced by deep water slope facies with low-stand deposits in Virginia, and their C-O isotope signature, all of which suggest significant periodic fourth order sea level changes during deposition.

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